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Methodology for Designing Cost-Effective Monitoring and Compliance Strategies for Pesticide Use

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September 1978

METHODOLOGY FOR DESIGNING COST-EFFECTIVE MONITORING AND COMPLIANCE STRATEGIES FOR PESTICIDE USE

by

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FOREWORD

Environmental protection efforts are increasingly directed towards preventing adverse health and ecological effects associated with specific compounds of natural or human origin. As part of this Laboratory's research on the occurrence, movement, transformation, impact, and control of environmental contaminants, the Technology Development and Applications Branch develops management and engineering tools for assessing or controlling toxic substances in the environment.

Efforts to ensure compliance with pesticide label requirements by many different users of thousands of Federally registered pesticides are hampered by a lack of information on the extent of misuse and limitations on resources to enforce control programs. This report demonstrates that, within current state-of-the-art technology and organizational structures, cost-effective strategies can be developed to minimize health and environmental damage from pesticide misuse. The methodology, however, must be evaluated by regulatory officials to determine whether it would be a useful tool for application to control programs before further development is undertaken.

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ABSTRACT

Under the Federal Insecticide, Fungicide and Rodenticide Act, it is unlawful for any person to use any registered pesticide in a manner inconsistent with its labeling (Section 12(a)(2)(G), as amended). This report demonstrates the necessity and feasibility of developing a methodology for designing cost-effective monitoring and compliance programs to deal with pesticide misuse.

The report provides (1) a conceptual framework that identifies different kinds of pesticide misuse, (2) a methodology for ranking potential misuses in terms of expected environmental and health damages, (3) a procedure for measuring adherence to pesticide label requirements by pesticide users, (4) a behavioral scheme to explain the occurrence of pesticide misuse, (5) alternative strategies to achieve pesticide label compliance, and (6) an assessment of the feasibility of and the need for designing cost-effective monitoring and compliance strategies for pesticide use.

Because such a methodology was found to be within the limits of current state-of-the-art technology and organizational structures, the report provides a generalized design technique for pesticide regulatory agencies. The methodology consists of techniques for analyzing the scope and effects of misuse, ranking misuse according to potential damages, monitoring misuse and damages, analyzing and modeling user procedures, and evaluating compliance strategies. Additional work would be required to develop specific compliance strategies from the general approaches presented.

Although the need to do such work is defensible, potential users must view the methodology as being a useful tool before the work is performed. Consequently, a series of recommendations are presented for further formulating, testing, and implementing the procedures presented in the report.

This report was submitted in fulfillment of Contract Number 68-03-2448 by CONSAD Research Corporation under the sponsorship of the U.S. Environmental Protection Agency. This report covers the period August 23, 1976, to September 15, 1977, and work was completed as of December 31, 1977.

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ACKNOWLEDGEMENTS

The cooperation and assistance of EPA personnel in the performance of this study is gratefully acknowledged. In particular, CONSAD would like to thank Mr. Anthony Dellavecchia, Mr. John Martin and Mr. John Ulfelder of the Pesticides and Toxic Substances Enforcement Division (PTSED), Office of Enforcement; Mr. William Holmberg and Ms. Ann Dizard, Operations Division, Office of Pesticide Programs; and Dr. Robert Reynolds, Economic Analysis Branch, Criteria and Evaluation Division, Office of Pesticide Programs.

CONSAD is also particularly indebted to Mr. Thomas Waddell, co-Project Officer, Office of Research and Development for his guidance, active support and interest in the successful completion of this project.

CHAPTER 1

EXECUTIVE SUMMARY

INTRODUCTION

Rationale for the Study

With the passage of the Federal Environmental Pesticide Control Act (FEPCA) into law on October 21, 1972 (PL 92-516), a new era in the control of the pesticide industry began. In amending the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) of 1947, FEPCA greatly expanded the regulation of chemical pesticides, including detailed provisions regarding pesticide registration, as well as registration of pesticide products sold only in intrastate commerce.

Furthermore, Congress, in recognizing the seriousness of, and the public's concern regarding the misuse of pesticides, provided EPA with the necessary tools to control the use and application of pesticides. Section 12 of FIFRA, as amended deals with unlawful acts and specifically, section 12(a)(2)(G) of FIFRA, as amended, states that "it shall be unlawful for any person to use any registered pesticide in a manner inconsistent with its labeling". Furthermore, sections 9, 13 and 14 of FIFRA, as amended, provide EPA with enforcement remedies, including establishment inspections, warning letters, civil penalties, criminal penalties, stop sale orders, stop use orders and seizures.

Both EPA and the Congress recognized that the interpretation of Section 12(a)(2)(G) would be difficult, but they also recognized that the standard "use inconsistent with the pesticide labeling" must be applied in a common sense manner, i.e.:

> "The Agency has taken the position that any use of a pesticide in contravention of its label provision is, strictly speaking, a violation of the FIFRA and may subject the violator to civil or criminal sanctions. Notwithstanding this narrow construction of Section 12(a)(2)(G), the Agency recognizes that the FIFRA, including Section 12(a)(2)(G), must be administered in a manner which will achieve compliance with the statutory mandate without placing unreasonable or unworkable burdens upon producers and users of pesticides."*

*Federal Register, May 5, 1975, Volume 40, page 19518.

Therefore, in interpreting and enforcing Section 12(a)(2)(G), the EPA has decided to entertain requests to issue pesticide use rulings on a case-by-case basis, and in this way, furnish its interpretation of the Act. By doing so, the Administrator of the EPA hopes to "provide a mechanism for the development of a uniform national policy regarding the enforcement of Section 12(a)(2)(G).*

Through the issuance of Pesticide Enforcement Policy Statements (PEPS) -- seven of which have been issued to date -- exceptions to EPA's narrow interpretation of Section 12(a)(2)(G) have and will continue to be explicated, and will further help to define those uses of pesticides (contrary to label instructions) where EPA will exercise its prosecutorial discretion.**

Nevertheless, the potentially broad and comprehensive nature of this section of the Act makes ensuring compliance with label requirements by users of registered pesticides a formidable undertaking because of the large number (about 28,000) of federally registered pesticides and the much larger number of users. Moreover, since resources available for misuse monitoring and compliance programs will be limited, the design of these programs must take into account both costs and program effectiveness in terms of allocating resources to minimize environmental damage from pesticide misuse.

A variety of potential strategies for achieving compliance with label requirements, ranging from strictly legal measures to reliance on educational extension information programs, are available. However, in addition to evaluating these strategies, the compliance program's design must include allocation of available monitoring and compliance resources among different types of pesticide misuse. Program costs must be quantified along with the measures of program effectiveness (for reducing or preventing environmental damage from pesticide misuse) that are needed to compare alternative compliance strategies.

Designing and implementing cost-effective monitoring and compliance programs is further complicated by the current lack of sufficient data and methods of collecting data on the extent of different kinds of pesticide misuse and resulting environmental damage. This information is needed for the design and implementation of cost-effective monitoring and compliance programs by the states and regions as a means of setting priorities in terms of the kinds of misuses to be identified and controlled.

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*Ibid.

**The U.S. Senate on July 29, 1977 (Senate Bill S1678) and the U.S. House of Representatives on October 31, 1977 (House Bill H8681) adopted amendments to FIFRA which would clarify the definition of "use in a manner inconsistent with its labeling" to cover any use of a pesticide not permitted by the labeling except for: 1) applying a pesticide at any dosage concentration or frequency less than that specified on the labeling; 2) applying a pesticide against any target pest not specified on the labeling if the application is to crop, animal, or site specified on the labeling; 3) employing any method of application not prohibited by the labeling; or 4) mixing a pesticide with a fertilizer not prohibited by the labeling.

Consequently, to further explore the area of pesticide misuse and the design of cost-effective monitoring and compliance strategies, this study was undertaken.

Project Objectives

The primary purpose of the project was to assess the feasibility of and need for developing a methodology for designing cost-effective monitoring and compliance programs applicable to Section 12(a)(2)(G) of FIFRA, as amended. Consequently, the project was of a research nature to determine whether or not systematic procedures could be developed in order to assist EPA, its ten regions and the 50 states in designing appropriate monitoring and compliance strategies that would minimize pesticide misuse and the resultant environmental and health damages. Moreover, for the purposes of the project, environmental and health damage refers to generally acute effects. Long term effects (including intergenerational health effects) were excluded from consideration because they are less obvious and more difficult to detect and any compliance strategy which reduces acute damages from misuse will have some reductive effect on long-term effects.

Therefore, the study was not actually to design specific monitoring and compliance strategies that should be used for increasing adherence with pesticide label requirements, but rather to see if a general methodology could be suggested and used for such design purposes. Hence, further work to test and operationalize the methodology would be necessary before it could be implemented, after which time EPA and other agencies would have a tool to use in designing monitoring and compliance strategies.

Study Approach

In order to achieve the objectives outlined above, a series of tasks were performed. They can be summarized as follows:

- Develop a conceptual framework that will identify and categorize different kinds of pesticide misuse;
- Develop a methodology for ranking potential misuses in terms of expected environmental and health damages;
- Develop a procedure for measuring adherence to pesticide label requirements by pesticide users;
- Develop a behavioral scheme to explain why pesticide misuses occur;
- Identify and evaluate alternative strategies to achieve compliance by pesticide users with the requirements of Section 12(a)(2)(G) of FIFRA, as amended; and

- Assess the feasibility and need of integrating the above tasks in order to develop a methodology for designing cost-effective monitoring and compliance strategies that will minimize health and environmental damage from pesticide misuse.

In addition, a variety of data sources were utilized in the performance of this project, e.g.:

- EPA Registration Guidelines and other regulations implementing the FIFRA, as amended;
- Pesticide Enforcement Policy Statements (PEPS);
- EPA personnel in the Office of Pesticide Programs (OPP) and in the Pesticides and Toxic Substances Enforcement Division (PTSED);
- EPA personnel in the Federal EPA regions (i.e., selected pesticide branch chiefs and members of their staff, e.g., Consumer Safety Officers);
- Pesticide regulatory personnel in selected states;
- Pesticide Episode Reporting System (PERS) data;
- Pesticide Misuse Review Committee (PMRC) pesticide misuse case files; and
- Research literature on human performance, human factors, industrial safety and accident prevention.

Subsequent chapters of this report indicate when and how each data source was utilized.

CONCLUSIONS

As previously indicated, the overall thrust of the present project was to assess whether or not a methodology for designing cost-effective regional and state pesticide misuse monitoring and compliance strategies could be developed for use by EPA, its 10 regions and the 50 states. In the following subsections, various conclusions concerning the feasibility of, and the need for, such a methodology are presented. These conclusions are based upon the tasks completed as part of this project.

Feasibility of Methodology Development

The concept of program feasibility implies that a given program is capable of being done or carried out in a successful manner with a "reasonable" amount of effort. When applied to developing a methodology for designing cost-effective monitoring and compliance strategies, the current project has indicated that such a methodology is within the limits of the state-of-the-art of technology and organizational structures, and therefore, it is feasible to develop such a methodology. Indeed, a general method for designing monitoring and compliance strategies has been produced by the present project and is described in detail in subsequent chapters of this report. To summarize, the components of this general method include:

- Methods for conceptualizing and analyzing the local level scope and effects of misuse;
- Methods for ranking misuse according to potential damages at the local level;
- Methods for local, state, and regional monitoring of misuse and damages;
- Methods for analyzing and modeling user procedures and behavior; and
- Methods for designing and evaluating compliance strategies.

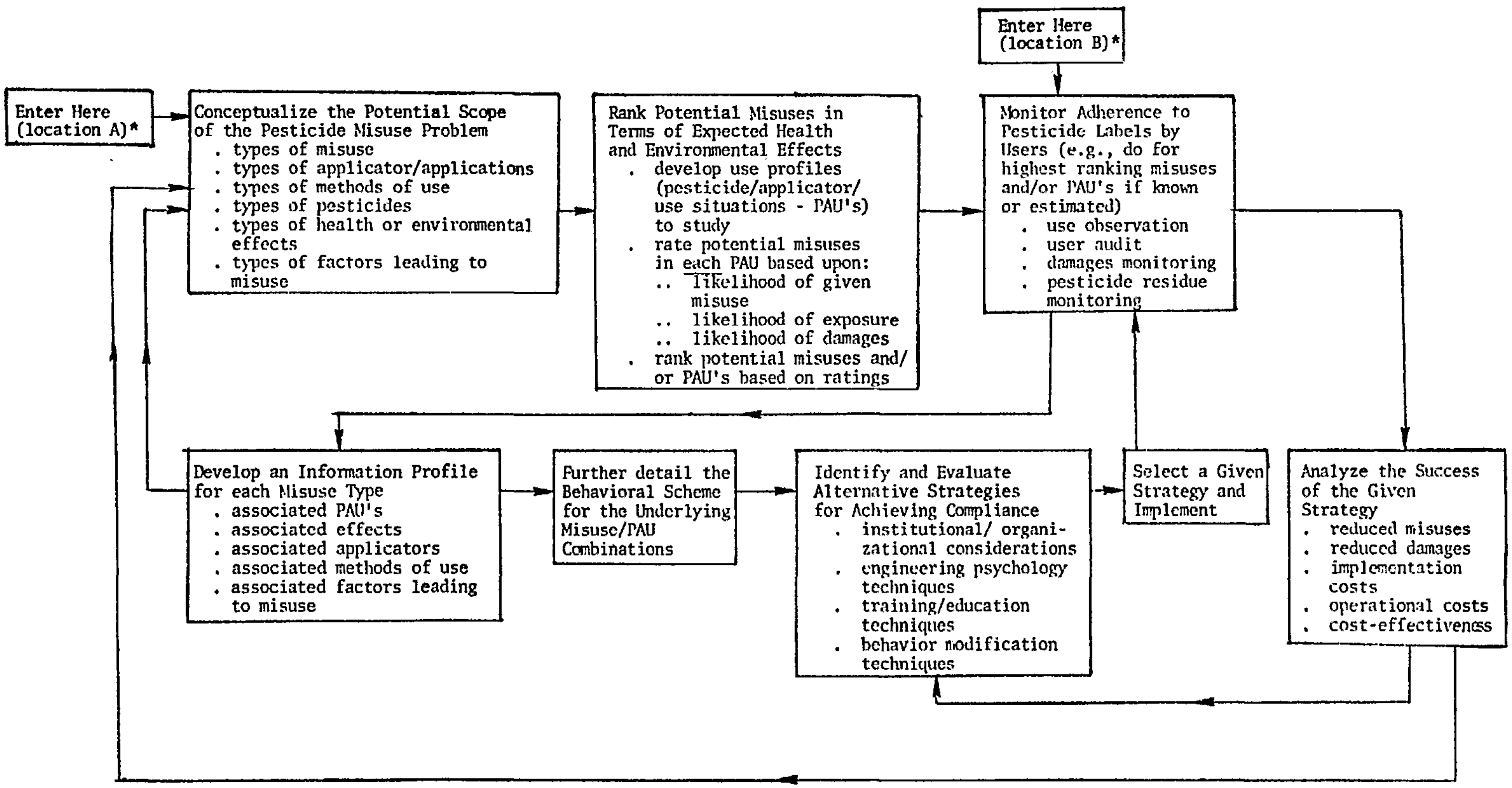
The inter-relationships of each of these methodological components are presented in Exhibit 1. Each component has been developed to the level needed to assess feasibility, and each one is now ready to be operationalized and implemented in the process of producing specific monitoring and compliance strategies.

For example, when monitoring and compliance strategies are to be selected and developed, it is useful first to analyze exactly what the context of the pesticide misuse involves, and what the general process of environmental dispersion is. Consequently, a conceptualization of the scope of the pesticide misuse problem is described in this report as the first step in developing a monitoring and compliance strategy. As more and more information on pesticide misuse is gathered and analyzed, this conceptualization can be refined and adjusted as is necessary.

The ranking of potential misuses in terms of expected health and environmental effects is the next step or component suggested for designing monitoring and compliance strategies. As indicated in the exhibit, pesticide use profiles must be developed as part of this component.

The importance of pesticide use profiles arises from the axiomatic relation between the technology and scope of use on one hand, and the volume dispersed through misuse on the other. This connection will vary for different types of application methods, crops, and industrial contexts, so that it is important to compile small area data sets on volumes and toxicities of pesticides involved in most uses. That is, the more complete the data on hand are about the various local pesticide/applicator/use situations (PAU's), the more precise and effective the monitoring and compliance strategies will be.

Exhibit 1: General Methodology for Designing Cost-Effective Pesticide Use Monitoring and Compliance Strategies



*Location A and Location B refer to the two points where the system user could begin using the methodology (see page 7 of the text).

Some estimation procedures will probably be required to fill out the use profile in many counties or multi-county regions. These estimations, if made by knowledgeable and experienced officials, can be quite accurate. For example, extension agents are experienced in estimating crop acreages, pesticide usage rates per acre and other statistical information. Therefore, a working series of use profile data could feasibly be developed with a reasonable amount of effort by extension agents, misuse investigators, and soil conservation personnel, with perhaps some inputs from the private sector.

A second and a third aspect of the ranking procedure are the rating and ranking, respectively, of the relative danger to the environment and human health from alternative pesticide misuses. Such assessment has long been a difficult task for regulatory and investigative agencies. The conclusions of the present project are that the probabilities of misuse, and of damages which result from misuses, should be estimated or "judged" by knowledgeable officials at the regional, state and local level, using a formalized estimating procedure, such as the one described in this report. These probabilities must be estimated in order to assess the relative hazard of various misuses, and yet the factors which determine these probabilities are so complex that a statistical model for estimating them would be erroneous even if such a model could be formulated and operationalized at the present. Therefore, the conclusion is reached that a judgment procedure should be used.

The actual monitoring of pesticide misuse -- i.e., monitoring adherence to label requirements -- can then be activated by using the two previous components to provide guidance as to where monitoring should take place. (Alternatively, the misuse researcher can begin at this point, i.e., location B in Exhibit 1, and later on return to these other components, i.e., location A in Exhibit 1, by following the feedback lines.) The compilation of misuse occurrence and damages data through use observation, user audit, damages monitoring and residue monitoring techniques, is the basic approach of the recommended Pesticide Label Adherence Information System (PLAINS). Although the feasibility for a large scale project of this type is not conclusive at present, the basic components and data files of such a system are readily identified. The procedures for collecting data from county health departments, hospitals, and physicians's offices would need to be tested for feasibility, while the inputs needed from park rangers and wildlife officials would probably be much easier to obtain. In addition, the structure of the monitoring procedures should eventually be designed to insure that data obtained on misuse occurrences and damages are adequate for the derivation of an information profile for various pesticide misuse types. At present, such profiles would be difficult to formulate in detail for a large number of misuse types. In addition, all existing dispersal and impact models will need to be reviewed and revised from the viewpoint of analyzing the results of misuse.

Once pesticide misuse monitoring has occurred and information profiles of the various misuse types are generated, a further delineation of the behavior "schemes" or models underlying misuse/PAU combinations must be made, so that alternate compliance strategies can be structured and evaluated. A preliminary description of the various behaviors antecedent to pesticide misuse, as well as the organizational and technical factors which impinge on these behaviors, is presented in this report and therefore, such a behavior is feasible. However, further analysis and structuring of the behavioral components are necessary, and will become possible as pesticide misuse monitoring techniques are further developed and operationalized to elicit and compile such information.

The method described in this report for identifying and evaluating compliance strategies relies on the above mentioned behavioral model, as well as on the information profile of various pesticide misuse types. This method will provide for the establishment of the general features of a compliance strategy program. These general features can utilize one or more of the following general approaches: institutional/organizational considerations; engineering psychology techniques; training/education techniques; and behavior modification techniques (which includes available legal remedies).

However, additional work is needed to develop and operationalize specific compliance strategies or techniques from these general approaches. Using the guidelines described in this report, the general compliance strategies described above can be adapted and applied to a particular type of misuse after the misuse has been identified and evaluated by the ranking system and the information profile. The precise mechanisms for structuring and operationalizing the exact compliance strategy are not "pre-definable", i.e., these mechanisms must arise from the misuse evaluation and subsequent procedures, and must be appropriate for the local/regional context in which the strategy will be used. The criteria and guidelines for selecting and defining the appropriate compliance strategy are, however, presented in this report. In other words, this report will enable the officials involved to proceed from knowledge of a type of misuse to a reasonably specific type of compliance strategy.

Since the final design, selection and implementation of a compliance strategy must be based on the local or regional institutional and administrative context, management techniques such as games, training courses, or organization development, can be used to develop specific strategies. For example, a conceivable and feasible procedure for this effort would be to select and define a proposed compliance strategy, and then use a role-playing or a game process to further develop and test the exact compliance technique. Thus, the behavior of pesticide dealers, users and misuse investigators could be simulated and modeled by officials playing the role of these types of people. For example, if the misuse problem and the guidelines and criteria outlined in this report suggested a legal process with fines as the type of compliance strategy to use, then a simulation of how the process should work -- and the reaction to the fines -- could be performed in a game or role-playing effort.

Subsequent monitoring of pesticide misuse can allow the misuse researcher to analyze a specific strategy's effectiveness in reducing misuse and damages. This will, in turn, allow him to redesign the compliance strategy and to update the scope of the pesticide misuse problem, i.e., "reconceptualize" the pesticide misuse problem. Thus, each component of the methodology would be reapplied at given intervals, each time utilizing a larger and more recent data base on pesticide misuse and the effectiveness of various compliance strategies.

Need for Methodology Development

Evidence of the need for methods to design monitoring and compliance strategies exists in the form of very complex cases of misuse where documentation is hard to develop. A review of over 200 case investigations from the Pesticide Misuse Review Committee (PMRC) files (described elsewhere in this report) shows that even the most diligent efforts by EPA Consumer Safety Officers or other investigators sometimes fail to give a comprehensive picture of all of the factors and effects of the misuse case. There is, in other words, no clear and simple restriction which could have prevented the misuse, and this fact applied to many misuse cases.

Further evidence of the need for methods to design monitoring and compliance strategies is in the form of "casual" misuse occurrences which do not immediately justify legal action or revocation of certification, but which cannot be ignored. These cases, which include "unforeseeable" spray drift, or failure to flush aircraft spray equipment properly and completely, may not entail complex (organizational) misuse behavior, but they can result in substantial crop and ornamental damage. Rather than spend substantial amounts of money attempting to relate degree of culpability to amount of damages (e.g., a legal strategy), a compliance strategy may be desirable which is more broad and general in the sense of preventing the antecedent conditions and behavior which enabled the ultimate misuse to occur.

The evidence of need for a broad range of compliance strategies also appears in the form of wide variations in institutions and technologies related to application itself. The variation extends across regions, crop types, and industrial contexts. The methods for devising compliance strategies, as described in this report, will enable the various regions, states and counties to devise and adapt compliance strategies which will be the most cost-effective for their situations.

Finally, the evidence of need for a methodology for designing cost-effective monitoring and compliance strategies rests in the fact that many agencies are involved (or get involved) in the enforcement of Section 12(a)(2)(G) of FIFRA, as amended. That is, the intention of FIFRA, as amended is to have each of the 50 states take primary responsibility for enforcing the provisions of the Act by working cooperatively with the EPA. However, Federal and state funds available to enforce Section 12(a)(2)(G) are limited. Consequently, to insure that each pesticide regulatory agency follows the best, most carefully designed procedure for monitoring and reducing pesticide misuse (i.e., to insure that Section 12(a)(2)(G) is enforced in a cost-effective and consistent manner across the United States), a broad methodology for designing a variety of cost-effective monitoring and compliance strategies will be a useful tool.

Nevertheless, although the above discussion has presented a rationale for further developing the methodology for designing cost-effective monitoring and compliance strategies, the need for such a methodology cannot be <u>fully</u> assessed until the potential users themselves (i.e., regulatory officials in the EPA regions and in the states) assess whether such a methodology would be a useful tool for developing programs *to* enforce Section 12(a)(2)(G) of FIFRA, as amended. Specifically, the appropriate regulatory officials in EPA and the states should determine the level of usefulness and acceptance among the potential users of this methodology before they decide whether or not such a methodology should be further developed.

RECOMMENDATIONS

In order to further test the feasibility of, and the need for a methodology for designing cost-effective monitoring and compliance strategies (including operationalizing and implementing the methods presented in this report), the following recommendations are made:

1. EPA should disseminate the methodology presented in this report among regulatory officials at the state and regional level in order to obtain feedback concerning the usefulness of operationalizing the procedures presented herein, i.e., would such procedures be welcomed and utilized?

2. The EPA could take further action by initiating a project to define the mechanism and procedures by which the enforcement role of PTSED, OPP, and the CSO's, can be enhanced with respect to other federal agencies, state govenment agencies, law enforcement groups, and academic resources (e.g., industrial extension services, industrial psychologists) in the various states.

3. Should the decision to further develop the proposed methodology be affirmative, appropriate EPA offices could support pilot projects in selected state agencies and/or regional EPA offices, to further develop, test and operationalize the various component methods presented in this report for designing monitoring and compliance strategies, e.g.:

   a. Projects could be initiated to develop detailed pesticide use profiles for a defined geographic area, and the ranking procedure could then be "tried out" utilizing knowledgeable officials and the judgment techniques suggested.

   b. Projects could be initiated with EPA regions and states to plan the scope and structure of the Pesticide Label Adherence Information System (PLAINS) described in this report, and to conduct trial implementations, including use/misuse modeling.

   c. Projects could be initiated by the National Enforcement Investigation Center (NEIC) or other appropriate agencies to develop complete detailed analytical models of selected pesticide use processes.

d. Comprehensive "in-depth" investigations of selected cases of misuse could be made where early reporting has already insured that good residue and toxicological data were obtained, in order to develop a complete background of the case so that improved behavior models can be developed.

e. A series of seminars and meetings could be sponsored so that regulatory officials, misuse investigators, industrial engineering psychologists, organizational psychologists, safety officials and others can come together to exchange ideas and approaches for achieving pesticide label compliance.

f. Projects could be initiated to evaluate the cooperative enforcement agreements between PTSED and the states to determine those compliance strategies most effective for given types of misuses and pesticide/applicator/use situations.

g. A project could be initiated to determine the usefulness of management techniques such as games and role-playing in 1) the development and testing of compliance strategies, and 2) as a method of training officials to devise new compliance strategies.

THE REMAINING CHAPTERS

Chapters 2 through 6 present further details concerning each component of the general methodology for designing cost-effective monitoring and compliance strategies. More specifically, Chapter 2 contains a conceptualization of the potential scope of the pesticide misuse problem including the types of misuse, applicator/application categories, methods of use involved, pesticides, health and environmental effects and factors leading to pesticide misuse. The ranking of potential misuses based upon expected health and environmental effects is then discussed in Chapter 3. Topics included are developing pesticide use profiles, rating misuses for various pesticide/applicator/use situations (PAU's), and ranking misuses and/or PAU's based on these ratings.

The Pesticide Label Adherence Information System (PLAINS), detailed in Chapter 4, presents various approaches for monitoring adherence to pesticide labels by pesticide users, e.g., pesticide use observation, pesticide user audit, damages monitoring and pesticide residue monitoring. Procedures that will enable the establishment of a baseline measure of the extent of misuse and the resultant environmental and health damages over time, as well as enable the evaluation of the effectiveness of alternate monitoring and compliance strategies are discussed.

The development of a behavioral model of pesticide misuse is next discussed in Chapter 5. Included are a discussion on analyzing the pesticide use process, results from reviewing the PMRC misuse case files, a more detailed discussion concerning the taxonomy of factors leading to pesticide misuse and some implications for compliance strategies.

The final chapter further discusses various strategies for modifying the behavior of pesticide users so that they comply with pesticide label requirements. Four general approaches are suggested, i.e., organizational/institutional considerations, engineering psychology techniques, training/education techniques and behavior modification techniques. Suggestions for further specifying these general approaches, so that they are applicable to specific misuse/PAU combinations, concludes the chapter.

CHAPTER 2

A CONCEPTUALIZATION OF THE POTENTIAL SCOPE OF THE PESTICIDE MISUSE PROBLEM

INTRODUCTION

In developing a methodology for designing cost-effective monitoring and compliance programs, conceptualizing the potential scope of the pesticide misuse problem is a first useful task so that, at the outset, the broadness of the required methodology can be determined. In this way, subsequent components of the methodology can be designed to accomodate all the necessary types of pesticide misuse and their associated characteristics.

Therefore, various taxonomies were developed in order to conceptualize the potential scope of the pesticide misuse problem. Included were taxonomies for the following characteristics:

- Pesticide misuse types;
- Pesticide classes;
- Applicator/application types;
- Methods of use;
- Potential health and environmental effects; and
- Factors leading to pesticide misuse.

TAXONOMY OF PESTICIDE MISUSE

In defining the types of pesticide misuse from a conceptual standpoint (i.e., in developing a taxonomy of pesticide misuse), the "narrow" EPA interpretation of Section 12(a)(2)(G) of FIFRA, as amended, has been utilized. That is, any use of a pesticide inconsistent with its labeling is considered to be a misuse, except in those instances where the EPA has exercised its presecutorial discretion by issuing Pesticide Enforcement Policy Statements (PEPS).*

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*Although the U.S. Senate on July 29, 1977 and the U.S. House of Representatives on October 31, 1977 adopted amendments to FIFRA which would modify the definition of "use in a manner inconsistent with its labeling" (see page 2), these amendments have not yet been signed into law. Consequently, EPA's "narrow" interpretation of Section 12(a)(2)(G) is used.

Moreover, "use" has been interpreted as it is defined in the EPA regulations, 40 CFR 162.3 (oo):

> The term "use" means any act of handling or release of a pesticide or exposure of man or the environment to a pesticide through acts, including but not limited to:
>
> (1) Application of a pesticide, including mixing and loading and any supervisory action in or near the area of application;
>
> (2) Storage actions for pesticides and pesticide containers; and
>
> (3) Disposal actions for pesticides and pesticide containers.
>
> (Use as defined here incorporates application. However, the certification requirement for certain restricted use pesticides only applies with respect to applications of such pesticides. Many aspects of use do not include application (e.g., storage, transportation) and hence are outside the requirement for certification.)

Therefore, the taxonomy presented in Exhibit 2 covers the full range of possible misuses (consistent with the EPA's interpretation of Section 12(a)(2)(G) of FIFRA, as amended) resulting from all kinds of pesticide use contexts. The categories (i.e., misuse type headings) utilized in the taxonomy are based upon information required on the label of pesticide products, as described in Section 162.10(i)(2) of Title 40 of the Code of Federal Regulations, i.e., "Contents of Directions for Use". Consequently, all possible pesticide misuses resulting from the use of all different types of pesticides by all different types of pesticide applicators for all different kinds of uses have been represented. Thus, when a particular pesticide/applicator/use situation (PAU), i.e., pesticide, applicator, target pest, site of application, is specified, some misuses delineated in the taxonomy will, of course, not be applicable.

Note should be also made that each misuse specified in Exhibit 2 should be viewed as an entity unto itself; i.e., the assumption is made that all use procedures, except the misuse specified, are in conformance with label requirements. This is not to say that one misuse delineated in the taxonomy cannot be coupled with or give rise to another misuse delineated in the typology. Indeed, a particular PAU may give rise to a misuse situation involving numerous pesticide misuse types delineated in Exhibit 2.

TAXONOMY OF PESTICIDE CLASSES

In studying the various kinds of pesticide misuses, one key dimension to help characterize the type of misuse committed is the type of pesticide involved. Section 152.3(ff) of Title 40 of the Code of Federal Regulations defines the meaning of the term "pesticide" and presents 16 classes of pesticides that cover the entire range of active ingredients that could be involved in pesticide mis-

Exhibit 2: Taxonomy of Pesticide Misuse

Type 1 Misuses: Improper Applicator Certification

A. Use of restricted use pesticide by non-certified applicator.
   1. Never applied for certification.
   2. Failed certification exam.
   3. Counterfeit certificate.

B. Use of restricted use pesticide by improperly certified applicator.
   1. Wrong category for certification.
   2. Fraudulently certified, i.e., provided fake credentials.

C. Use of restricted use pesticide by an applicator who is not under proper supervision of a certified applicator.
   1. Insufficient directions from certified applicator.
   2. Not under direct supervision, i.e., certified applicator not available for guidance.
      a. Geographically absent.
      b. Not available even though in vicinity.
   3. Other

Type 2 Misuses: Improper Application Site (assumes pesticide used at the designated application site to control a specific pest problem)

A. Plants, crops, agricultural commodities, and soils.
   1. Incorrect target plant, crop, agricultural commodity or soil, i.e., no label status for the application site.
   2. Incorrect plant part, e.g., fruit instead of foilage.
   3. Incorrect growth stage, e.g., mature instead of seedling.
   4. Incorrect soil placement, e.g., too deep or shallow.
   5. Other

B. Domestic animals.
   1. Incorrect target animal, i.e., no label status for the application site.
   2. Incorrect part of the anatomy.
   3. Incorrect growth stage or age of animal.
   4. Other.

C. Wildlife.
   1. Incorrect target animal, i.e., no label status for the application site.
   2. Incorrect part of anatomy.
   3. Incorrect growth stage or age of animal.
   4. Other

D. Structures (i.e., homes, business/industry/institutional establishments, food handling establishments, commodity and food products storage facilities, water supplied for human consumption, farm animal facilities, populated areas, etc.).
   1. Incorrect target site, i.e., no label status for the application site.
   2. Wrong location, i.e., on exposed surfaces rather than in concealed or protected areas.
   3. Incorrect phase or stage of manufacturing processes.
   4. Other

Exhibit 2: Taxonomy of Pesticide Misuse (Continued)

E. Human Beings.
   1. Incorrect target, i.e., no label status for use on human beings.
      a. Suicide attempt.
      b. Homicide attempt.
      c. Other.

F. Aquatic areas, i.e., no label status for use in aquatic areas.

Type 3 Misuses: Improper or Non-existent Target Pest

A. Pest not listed on label, i.e., all use procedures except target pest are in conformance.
   1. For structural pest control - applicator not expert or did not receive written recommendation from knowledgeable expert (i.e., not in conformance with PEPS Number 2).
   2. For agricultural and non-structural pest control - applicator not expert or did not receive written recommendation from knowledgeable expert (i.e., not in conformance with PEPS Number 5).

B. Non-existent target pest, i.e., improper preventive pest control treatments in the absence of target pests (i.e., not in conformance with PEPS Number 4).
   1. Target pest not listed on the label.
   2. Preventive treatments prohibited on the label.
   3. Non-existent target pest not expected to infest the area to be treated.

Type 4 Misues: Improper Dosage Pates

A. Single application in excess of label rate, e.g., improper use dilution and/or pressure and/or vehicle speed.

B. Multiple applications in excess of label rate (e.g., improper use dilution and/or pressure and/or vehicle speed) resulting in excessive cumulative dosage.

C. Applications less that label rate (e.g., improper use dilution and/or pressure and/or vehicle speed) where no written recommendation or where specifically prohibited by label (i.e., not in conformance with PEPS Number 1).

Type 5 Misuses: Improper Frequency or Timing of Applications

A. Greater total number of applications than label specified resulting in excessive cumulative dosage.

B. Fewer total number of applications than label specified.

C. Incorrect growth stage of the target pest, e.g., adult instead of larva.

D. Other.

Exhibit 2: Taxonomy of Pesticide Misuse (Continued)

Type 6 Misuses: Improper Application Equipment and/or Use of a Particular Formulation Type

A. Improper application equipment used.
   1. Aerial application (fixed wing or helicopter) of pesticides inconsistent with provisions of PEPS Number 7.
      a. Aerial application of pesticides having Category II labels.
      b. Aerial application of pesticides having Category III or IV labels <u>without</u> state authorization via a 24(c) state registration or other statutory mechanism.
      c. Aerial application of pesticide having Category V or VI labels <u>without</u> recommendation from knowledgeable expert or satisfying other PEPS Number 7 requirements.
   2. On ground application of pesticided labelled for aerial application.
   3. Improper component parts (e.g., spray nozzles) on application equipment.
   4. Other.
B. Wrong use of a particular formulation type.
   1. Wettable powder used as dust or granules for dry treatment or vice versa.
   2. Aerosol formulation used to produce wettable powder or emulsifiable concentrate type of surface deposit.
   3. Structural formulation used for plant or animal treatment or vice versa.
   4. Improper diluent or additives or improper reformulation.
   5. Other
C. Improper repackaging of a pesticide product.
   1. Strictly prohibited on label.
   2. Harmful effects outweigh beneficial effects.

Type 7 Misuses: Improper Protective Clothing

A. No protective clothing worn.
B. Inadequate choice and/or use of clothing and equipment.
   1. Permeable to pesticide.
   2. Incorrect respirator, gas mask filter pads or cartridges.
   3. Clothing and equipment not properly worn or maintained.

Type 8 Misuses: Insufficient Time Between Application and Site Re-Entry

A. For agricultural commodities.
B. For crops, fields, plants.
C. For structures.
   1. Commodity and food products storage facilities.
   2. Food and feed processing facilities.
   3. Farm animal facilities (e.g., barns, corrals, etc.).
   4. Miscellaneous business/industry/institutional establishments including food handling establishments.
   5. Households and homes.

Exhibit 2: Taxonomy of Pesticide Misuse (Continued)

Type 9 Misuses: Improper Use Procedures and Care with Regard to Protection of Human Health and the Environment during Pesticide Use, i.e., failure to follow restrictions or limitations.

A. Pesticide applications too close to food or feed crop harvest or animal slaughter (e.g., pre-harvest intervals not adhered to
B. Rotational crop restrictions not adhered to.
C. Improper transport, mixing, loading or application, potentially resulting in direct contact (e.g., ingestion, inhalation, plant or crop exposure, etc.) at a site separate from but associated with a designated application site.
D. Improper transport, mixing, loading or application, potentially resulting in pesticide spills.
E. Improper transport, mixing, loading or application, (e.g., when wind speed is wrong), potentially resulting in indirect contact (e.g., spray drift).
F. Improper transport, mixing, loading or application, potentially resulting in fire or explosion.
G. Improper transport, mixing, loading or application, potentially resulting in pesticide run-off, erosion, or leaching.
H. Improper transport, mixing, loading or application, potentially resulting in ingestion of pesticide treated seed by domesticated animals.
I. Improper transport, mixing, loading or application, potentially resulting in stream, or lake contact by animals properly treated externally with pesticides.
J. Pesticide applications while bees are active in violation of the label.

Type 10 Misuses: Improper Storage of Pesticides and Pesticide Containers and Improper Disposal of Pesticides and Empty Containers

A. Storage facilities and practices for pesticide and/or pesticide containers not in concurrence with the label or 40 CFR 165.
   1. Public has access.
   2. Fire hazard.
   3. Deficient housekeeping and cross-contamination of pesticide products.
   4. Lack of warning signs and identification.
   5. Lack of decontamination facilities.
   6. No control of run-off water.
   7. Other.
B. Disposal practices for pesticides and/or pesticide containers not in concurrence with label or 40 CFR 165.
   1. Open dumping (e.g., into soils, into non-approved landfilles, etc.).
   2. Open burning (except for small numbers of empty containers that do not contain arsenic, lead, mercury, cadmium).
   3. Water dumping.
      a. Direct placement in water.
      b. Run-off water.
   4. Spillage (resulting in exposed pesticide residue).
   5. Faulty incineration with concurrent escape of volatie pesticides.
   6. Reuse of empty containers when prohibited on the label.
   7. Use of pesticide treated seed for animal feed.
   8. Other.

use cases. Exhibit 3 reproduces this list of pesticide classes and was utilized throughout the study to conceptualize the types of pesticides that could be involved in any given misuse case.

Exhibit 3: Taxonomy of Pesticide Classes

Class 1 Pesticides: Amphibian and reptile poisons and repellents

Class 2 Pesticides: Antimicrobial agents

Class 3 Pesticides: Attractants

Class 4 Pesticides: Bird poisons and repellents

Class 5 Pesticides: Defoliants

Class 6 Pesticides: Desiccants

Class 7 Pesticides: Fish poisons and repellents

Class 8 Pesticides: Fungicides

Class 9 Pesticides: Herbicides

Class 10 Pesticides: Insecticides

Class 11 Pesticides: Invertebrate animal poisons and repellents

Class 12 Pesticides: Mammal poisons and repellents

Class 13 Pesticides: Nematicides

Class 14 Pesticides: Plant regulators

Class 15 Pesticides: Rodenticides

Class 16 Pesticides: Slimicides

TAXONOMY OF APPLICATOR/APPLICATION TYPES

A second dimension that was found to be useful to describe any given type of misuse was the type of applicator and application that could be involved. Exhibit 4 presents a two dimensional taxonomy to conceptualize the possible applicator/application categories that could be associated with a pesticide misuse.

The reader will note that the application types correspond to the commercial applicator certification categories described in Section 171.3(b) of Title 40 of the Code of Federal Regulations, i.e., "Categorization of Commercial Applicators of Pesticides". However, their purpose in this taxonomy is primarily to describe the application sites (or purposes for using pesticides) that could be involved in (or associated with) pesticide misuse. Therefore, they are not meant to apply only to commercial applicators who are certified to use restricted use pesticides.

The second dimension of this taxonomy, i.e., type of applicator, is designed to describe the various types of pesticide applicators, regardless of whether they are certified to use restricted use pesticides. Similarly, commercial applicators, as defined by Section 171.2(i) of Title 40 of the Code of Federal Regulations would be represented by applicator types D, E, F, G, or H; however, these applicator types would also include non-certified users.

To further illustrate the meaning of the taxonomy, the following examples are given:

- Farmers of agricultural commodities or their employees who apply their own pesticides would be classified as Type 1A or 1B;
- Applicators who apply pesticides to agricultural commodities for their livelihood, e.g., aerial applicators, would be classified as Type 1F;
- Landscaping services or tree services who use pesticides would be classified as Type 4F;
- Owners, managers or employees of industrial firms who use pesticides on their own premises would be classified as Type 8D or 8E;
- Pesticide users associated with structural pest control operator (PCO) firms would be classified as Type 8F; and
- County employees applying pesticides for mosquito control programs would be classified as Type 9G.

As a final note, certain applicator/application categories are not possible (these are designated by a horizontal line through the appropriate cells)

Exhibit 4: Taxonomy of Applicator/Application Types

Type of Application* \ Type of Applicator	A Private applicator, i.e., an individual producing an agricultural commodity, as defined in 40 CFR 171.2(e), on property owned or rented by him	B Employee of a private applicator	C Home owner	D Owner or manager of a non-agricultural commodity producing firm, applying pesticides on firm's premises, property or equipment ("in-house personnel")	E Employee of a non-agricultural commodity producing firm, applying pesticides on firm's premises, property or equipment ("in-house personnel")	F "For hire" applicator applying pesticides to property not owned or rented by his firm, who may or may not distribute and/or sell pesticides	G Government agency (Federal, state, local) using own employees	H Pesticide manufacturer or manufacturer's technical sales representative or agent who is not a "for hire" applicator
1. Agricultural pest control-plant (including stored or partially processed products in warehouses or other containers)								
2. Agricultural pest control-animal (including stored or partially processed animal products)								
3. Forest pest control			—	—	—			
4. Ornamental and turf pest control								
5. Seed treatment			—					
6. Aquatic pest control								
7. Right-of-way pest control	—	—	—					
8. Industrial, institutional, structural and health-related pest control (including food and animal products in final processing and structures and equipment involved)								
9. Public health pest control	—	—	—	—	—	—		—
10. Regulatory pest control	—	—	—	—	—	—		—
11. Demonstration and research pest control	—	—	—	—	—	—		

*Categories described in 40 CFR 171.3(b).

Note: Horizontal lines in cells indicate that the applicator/application category is not possible. All other cells are defined by the application type number and the applicator type letter e.g., the first row-first column cell is a type 1A category.

due to the definitions of the applicator type and application type (e.g., public health and regulatory pest control can only be undertaken by government employees).

TAXONOMY OF METHODS OF USE

The process of using pesticides requires a complex set and sequence of tasks and this set and sequence vary from one pesticide use situation to another. Nevertheless, a given pesticide misuse arises when a particular task in this set and sequence of tasks is performed improperly. Consequently, to further characterize a pesticide misuse, it is desirable to associate the given misuse with the particular task being performed when the misuse occurred.

To assist in this process, a taxonomy of methods of use was developed (see Exhibit 5). Seven basic methods of use are identified. The different application methods is the most detailed method of use presented. As indicated in the exhibit, pesticide misuse can occur during the transport, mixing, loading, storage, disposal and reformulating or repackaging tasks, as well as during the actual task of applying the pesticide. Moreover, the pesticide misuse can involve the pesticide itself and/or the pesticide container.

TAXONOMY OF POTENTIAL HEALTH AND ENVIRONMENTAL EFFECTS FROM PESTICIDE MISUSE

The purpose of this section is to conceptualize the range of potential impacts as a result of pesticide exposure caused by pesticide misuse. As indicated in the project's objectives, intergenerational effects and/or other effects having long latency periods are excluded because they are less obvious and more difficult to detect.

A taxonomy has been developed based upon the following assumptions:

- A pesticide misuse may or may not result in pesticide exposure to a particular non-target entity;
- If pesticide exposure does occur to a particular non-target entity, then this event may or may not cause health effects and/or environmental effects; and
- The severity of the effects can vary.

Therefore, the taxonomy in Exhibit 6 delineates the entities that could be exposed and then, for each entity, the range of effects (other than no effect) that could result. For human health effects, detail is given to the exposure route and to the possible effects. For environmental effects. detail is given to the entities that could be exposed and to the possible effects, given that the exposure route may be difficult to detect.

Naturally, more than one entity delineated in the taxonomy can be affected by any given misuse and some types of effects can give rise to others (e.g., contamination to animal feed can result in contamination to food for

Exhibit 5: Taxonomy of Methods of Use

Type 1 Use: Transporting of pesticide or pesticide container involved

A. Pesticide involved
B. Pesticide container involved

Type 2 Use: Mixing of pesticide to proper use dilution (including calibration of application equipment)

Type 3 Use: Loading of pesticide into application equipment involved

Type 4 Use: Application of pesticide involved

A. Aerial application
    1. liquid spray
    2. granules
    3. dust
B. Ground application
    1. liquid spray
        a. machine
        b. hand sprayer
    2. broadcast pellets (granules)
        a. machine
        b. manual
    3. baits
    4. soil injection
    5. seed treatment
    6. painting
    7. pouring in or on
    8. dipping
    9. dusting
    10. fumigation
    11. tube or hose injection into a body of water
    12. fogging
    13. other

Type 5 Use: Storage of pesticide or pesticide container involved

A. Pesticide involved
B. Pesticide container involved

Type 6 Use: Disposal of pesticide or pesticide container involved (including cleaning of mixing, loading and application equipment and protective clothing)

A. Pesticide involved
B. Pesticide container involved

Type 7 Use: Reformulating or repackaging of pesticide involved

Exhibit 6: Taxonomy of Potential Health and Environmenal Effects

Type 1 Effects: Health Effects - Occupationally Exposed

A. Exposure route: skin and/or eyes
   1. Morbidity
      a. acute minor
      b. subacute minor
      c. chronic minor
      d. acute major
      e. subacute major
      f. chronic major
      g. permanent disability resulting from acute, subacute, or chronic major morbidity
   2. Mortality
      a. immediate, following acute major morbidity
      b. delayed, following subacute or chronic major morbidity
      c. both inmediate and delayed (may be applicable when more than one person is involved in a particular pesticide exposure)
B. Exposure route: respiratory tract
   1. Morbidity
      a. acute minor
      b. subacute minor
      c. chronic minor
      d. acute major
      e. subacute major
      f. chronic major
      g. permanent disability resulting from acute, subacute, or chronic major morbidity
   2. Mortality
      a. immediate, following acute major morbidity
      b. delayed, following subacute or chronic major morbidity
      c. both immediate and delayed (may be applicable when more than one person is involved in a particular pesticide exposure)
C. Exposure route: mouth
   1. Morbidity
      a. acute minor
      b. subacute minor
      c. chronic minor
      d. acute major
      e. subacute major
      f. chronic major
      g. permanent disability resulting from acute, subacute, or chronic major morbidity
   2. Mortality
      a. immediate, following acute major morbidity
      b. delayed, following subacute or chronic major morbidity
      c. both immediate and delayed (may be applicable when more than one person is involved in a particular pesticide exposure)

Exhibit 6: Taxonomy of Potential Health and Environmental Effects (Continued)

Type 2 Effects: Health Effects - Non-Occupationally Exposed

A. Exposure route: skin and/or eyes
  1. Morbidity
    a. acute minor
    b. subacute minor
    c. chronic minor
    d. acute major
    e. subacute major
    f. chronic major
    g. permanent disability resulting from acute, subacute, or chronic major morbidity
  2. Mortality
    a. immediate, following acute major morbidity
    b. delayed, following subacute or chronic major morbidity
    c. both immediate and delayed (may be applicable when more than.one person is involved in a particular pesticide exposure)

B. Exposure route: respiratory tract
  1. Morbidity
    a. acute minor
    b. subacute minor
    c. chronic minor
    d. acute major
    e. subacute major
    f. chronic major
    g. permanent disability resulting from acute, subacute, or chronic major morbidity
  2. Mortality
    a. immediate, following acute major morbidity
    b. delayed, following subacute or chronic major morbidity
    c. both immediate and delayed (may be applicable when more than one person is involved in a particular pesticide exposure)

C. Exposure route: mouth
  1. Morbidity
    a. acute minor
    b. subacute minor
    c. chronic minor
    d. acute major
    e. subacute major
    f. chronic major
    g. permanent disability resulting from acute, subacute, or chronic major morbidity
  2. Mortality
    a. immediate, following acute major morbidity
    b. delayed, following subacute or chronic major morbidity
    c. both immediate and delayed (may be applicable when more than one person is involved in a particular pesticide exposure)

Exhibit 6: Taxonomy of Potential Health and Environmental Effects (Continued)

Type 3 Effects: Environmental Effects - Domestic Animals

A. Farm animals (e.g., cattle, horses, swine, sheep, poultry, etc.)
   1. Acute morbidity
   2. Subacute morbidity
   3. Chronic morbidity
   4. Immediate mortality following acute morbidity
   5. Delayed mortality following subacute or chronic morbidity
   6. Both immediate and delayed mortality (may be applicable when more than one animal is involved in a particular pesticide exposure)

B. Household pets
   1. Acute morbidity
   2. Subacute morbidity
   3. Chronic morbidity
   4. Immediate mortality following acute morbidity
   5. Delayed mortality following subacute or chronic morbidity
   6. Both immediate and delayed mortality (may be applicable when more than one animal is involved in a particular pesticide exposure)

Type 4 Effects: Environmental Effects - Wildlife

A. Mammals
   1. Acute morbidity
   2. Subacute morbidity
   3. Chronic morbidity
   4. Immediate mortality following acute morbidity
   5. Delayed mortality following subacute or chronic morbidity
   6. Both immediate and delayed mortality

B. Birds
   1. Acute morbidity
   2. Subacute morbidity
   3. Chronic morbidity
   4. Immediate mortality following acute morbidity
   5. Delayed mortality following subacute or chronic morbidity
   6. Both immediate and delayed mortality

C. Fish and reptiles
   1. Acute morbidity
   2. Subacute morbidity
   3. Chronic morbidity
   4. Immediate mortality following acute morbidity
   5. Delayed mortality following subacute or chronic morbidity
   6. Both immediate and delayed mortality

Exhibit 6: Taxonomy of Potential Health and Environmental Effects (Continued)

D. Aquatic organisms other than fish
   1. Immediate mortality following acute morbidity
   2. Delayed mortality following subacute or chronic morbidity
   3. Both immediate and delayed mortality

E. Bees and other insects
   1. Immediate mortality following acute morbidity
   2. Delayed mortality following subacute or chronic morbidity-
   3. Both immediate and delayed mortality.

F. Other
   1. Acute morbidity
   2. Subacute morbidity
   3. Chronic morbidity
   4. Immediate mortality following acute morbidity
   5. Delayed mortality following subacute or chronic morbidity
   6. Both immediate and delayed mortality

Type 5 Effects: Environmental Effects - Soils, Agricultural Commodities, Crops or Plant Life (the effect would be contamination and/or damage to the entities below)

A. Soils

B. Agricultural commodities
   1. Food for human consumption (including animal and Poultry products, grains, fruits, vegetables)
   2. Food for animals (including forage, silage or grain crops, oils, animal by-products), the products of which are intended for human consumption

C. Crops

D. Pastureland and rangeland

E. Forests

F. Home gardens and household grounds

G. Ornamentals, landscapes, trees, turfgrass, etc. (including rights-of-way)

H. Streams, lakes and other aquatic environments

I. Other

Type 6 Effects: Environmental Effects - Structures (the effect would be contamination and/or damage to the entities below)

A. Households and homes

B. Business and industry establishments (including food processing facilities)

C. Food handling establishments (e.g., restaurants, grocery stores, etc.)

D. Institutional establishments

E. Commodity and food products storage facilities (e.g., grain elevators, railroad cars, warehouses, etc.)

F. Water supplies for human consumption and use

G. Farm animal facilities (e.g., barns, corrals, etc.)

H. Other

human consumption and/or illness or death to animals). However, note should be made that a particular kind of misuse associated with a given PAU does not have the potential to give rise to all of the effects delineated. Indeed, the likelihood that a certain entity will be exposed and affected by a given misuse is, of course, dependent upon the particular PAU in question.

To assist the reader in using the taxonomy, the following definitions are provided:

Health Effects

- Acute minor morbidity: A one-time short-lived symptom or irritation, immediately following a pesticide exposure, and requiring at most minor medical attention.

- Subacute minor morbidity: A one-time short-lived symptom or irritation, following a pesticide exposure but delayed in manifesting itself, and requiring at most minor medical attention.

- Chronic minor morbidity: A recurring symptom or irritation, possibly delayed in initially manifesting itself, resulting from either a "one-time" pesticide exposure or pesticide exposures extending over a period of time, and requiring at most minor medical attention.

- Acute major morbidity: A one-time short-lived symptom or serious physiologic dysfunction, immediately following a pesticide exposure, and requiring intensive medical care including hospitalization.

- Subactue major morbidity: A one-time short-lived symptom or serious physiologic dysfunction, following a pesticide exposure but delayed in manifesting itself, and requiring intensive medical care including hospitalization.

- Chronic major morbidity: A recurring symptom or serious physiologic dysfunction, possibly delayed in initially manifesting itself, resulting from either a "one-time" pesticide exposure or pesticide exposures extending over a period of time, and requiring intensive medical care including hospitalization.

- Permanent disability resulting from acute, subacute or chronic major morbidity: a health effect that is irreversible, e.g., loss of sight, disfiguration, etc.

Environmental Effects

- Acute morbidity: A one-time short-lived effect, immediately following a pesticide exposure.

- Subacute morbidity: A one-time short-lived effect, following a pesticide exposure but delayed in manifesting itself.

- Chronic morbidity: A recurring effect, possibly delayed in initially manifesting itself, resulting from either a "one-time" pesticide exposure or pesticide exposures extending over a period of time.

TAXONOMY OF FACTORS LEADING TO PESTICIDE MISUSE

The final dimension used to conceptualize the potential scope of the pesticide misuse problem is those factors that explain why pesticide misuses occur. The importance of understanding what contributes to a user misusing a pesticide is brought about because evaluating alternative compliance strategies to achieve adherence with label requirements is a major objective of the study. That is, in order to develop cost-effective strategies to reduce misuse, the strategies must deal directly with the behavior that must be changed.

These needs and requirements led to the development of a taxonomy of factors leading to pesticide misuse (see Exhibit 7).

The following assumptions underlie this taxonomy:

- The actual types of behavior leading to pesticide misuse are complex, varied and numerous;

- A given misuse occurrence probably has more than one identifiable, contributing behavior factor; and

- These factors are not necessarily the same for the type of misuse committed by different users.

In reviewing the taxonomy, the reader will no doubt note that the last two major factors in the taxonomy, intervening natural conditions and product lable deficiency, are not types of behavior, but are external conditions which stimulate distinctive kinds of behavior and distinctive kinds of misuse.

Exhibit 7: Taxonomy of Factors Leading to Pesticide Misuse

Type 1 Factors: Motivation to Misuse Pesticides

A. Economic incentives (i.e., to user's self interest)
   1. For "not for hire" applicators
      a. Crops, agricultural commodities, etc.
         1. higher yields can be obtained or are sought
         2. lower crop production costs (i.e., pest control costs) can he obtained or are sought
         3. meet harvest deadlines
         4. meet market fluctuations
         5. other
      b. Non-agricultural use situations
         1. the "best" control of the pest problem can be obtained or is sought (e.g., eliminate pest species "once and for all")
         2. lower pest control costs can be obtained or are sought
         3. other
   2. For "for hire" applicators
      a. Crops, agricultural commodities, etc.
         1. desire to reduce cost, time and/or complexity of post control operation (e.g., by limiting the number of different pesticides used, by encouraging use of particular pesticides, etc.)
         2. desire to increase sales (e.g., desire to please the customer)
         3. other
      b. Non-agricultural use situations
         1. desire to reduce cost, time and/or complexity of pest control operation (e.g., by limiting the number of different pesticides used, by encouraging use of particular pesticides. etc.j
         2. desire to increase sales (e.g., desire to please the customer)
         3. other

B. Pride
   1. Importance of aesthetic quality (e.g., "perfect" golf green, garden, shrubs, lawn, etc.)
   2. Importance of high yields

C. Institutional constraints
   1. No registered pesticide exists for use situation
   2. Registered pesticides for use situation not available (i.e., sold out)
   3. Proper equipment cannot be obtained (e.g., no equipment outlet, equipment will not be supplied by employer)
   4. Knowledgeable experts not available (e.g., incorrect advice received from extension service)
   5. Proper disposal sites not in existence
      a. Payoffs from manufacturers or wholesalers for selling specific pesticides
      b. Excessive desire to boost sales, move high quantities
      c. desire to simplify stock by reducing variety of materials sold
      d. desire to reduce storage of leftover materials and to reduce material and container disposal costs
   7. Other

D. User constraints [i.e., user cannot afford to adhere to label requirements although he may know it is not his self interest)
   1. Protective clothing too expensive
   2. Proper application equipment cannot be afforded
   3. Proper maintenance of application equipment cannot be afforded, i.e., use of faulty equipment
   4. Other

Exhibit 7: Taxonomy of Factors Leading to Pesticide Misuse (Continued)

Type 2 Factors: Physical/Psychological Condition of User

A. Fatigue (e.g., "over worked")
B. Illness
   1. Effects of weather
   2. Effects of pesticide exposure
   3. Other
C. Psychological state of user
   1. Mental illness
   2. Mental attitude
      a. willful disregard for environmental protection or safety of human health
      b. hatred for employer, job, neighbor, etc.

Type 3 Factors: Physical Ability of User

A. Age - too old or too young to properly use pesticides
B. Physical weakness
C. Physical disability (e.g., lacked use of hands, arms, etc.)
D. Visual disability

Type 4 Factors: Training of User

A. Basic educational lack
   1. Low general education
   2. Cannot follow directions
   3. Cannot read well (e.g., cannot understand use instructions or precautionary statements)
B. Ignorance about pesticides
   1. Lack of experience (e.g., "new on the job")
   2. Lack of proper supervision for inexperienced personnel
   3. Not trained adequately in basic pesticide use practices
   4. Not trained adequately to use particular pesticides
   5. Not aware that use inconsistent with labeling is a violation of Federal law (i.e., Section 12(a) (2) (G) of FIFRA, as amended)
C. Carelessness or negligence
   1. Precautionary statements not fully read, forgotten or not taken seriously
   2. General organizational failure in specifying tasks and precautions (e.g., lack of teamwork and coordination)
   3. Failure to distinguish among two or more pesticides leading to improper generalization of procedures or precautions
   4. Failure to request necessary assistance
   5. Other

Type 5 Factors: Intervening social conditions

A. Local custom (e.g., many people have done it repeatedly over time
B. Habit (e.g., individual applicator has done it repeatedly over time

Type 6 Factors: Intervening natural conditions

A. Sudden windstorm
B. Sudden rainstorm
C. Unforeseen and excessive temperatures (too hot or too cold)
D. Unforeseen and excessive drought
E. Unpredictable infestations
F. Sudden malfunction of application equipment (e.g., faulty equipment design)
G. Other

Type 7 Factors: Product Label Deficiency

A. Precautionary statements not sufficient to prevent potential adverse effects
B. Restrictions and limitations not sufficient to prevent potential adverse effects
C. Use instructions not sufficient to insure proper use (e.g., FIFRA Section 12(a)(2)(G) warning does not appear on the label)
D. Other

CHAPTER 3

METHODOLOGY FOR RANKING POTENTIAL PESTICIDE MISUSES IN TERMS OF EXPECTED HEALTH AND ENVIRONMENTAL EFFECTS

INTRODUCTION

Purpose

The purpose of the ranking procedure described in this chapter is to provide a methodology for selecting particular potential pesticide misuses for further in depth study (such as actually monitoring the extent of these types of pesticide misuse amongst pesticide users). The basis used for selecting potential misuses is the estimated or anticipated health and environmental effects resulting from the pesticide misuse (long term intergenerational effects excluded). Therefore, this procedure is intended to provide a framework for assigning a rating to different kinds of pesticide misuses, based upon the predicted scope and severity of the health and environmental effects expected to result from the misuse. In addition, the procedure attempts to provide guidance for properly interpreting and utilizing these ratings.

Overview

The methodology or ranking procedure described herein is based on the premise that the damages that occur from the misuse of pesticides is a function of a very complex set of interrelated factors. Thus, no precise method or system can be delineated for predicting such occurrences. Nevertheless, a guide to estimating the damages from one type of misuse relative to another type of misuse (i.e., a ranking procedure) is plausible if simplifying assumptions are made (e.g., the magnitude of misuse is correlated to the number of pounds of a pesticide applied and to the number of applicators applying the pesticide) and if subjective judgment techniques are used to estimate various types of information (e.g. , percent of the pesticide misused in a certain misuse, etc.) that would normally be available only after actual monitoring of pesticide misuse took place.

Specifically, the methodology or ranking procedure described herein consists of three steps, i.e.:

- Step One - developing a pesticide profile;
- Step Two - developing a rating for a particular misuse and a particular health or environmental effect; and

- Step Three - interpreting the ratings and ranking potential pesticide misuses.

The purpose of Step One -- developing a pesticide use profile -- is to provide a basis for continuing with Step Two of the ranking procedure. That is, the ratings for a particular misuse and a particular health or environmental effect must be made for a specific pesticide/applicator/use situation (PAU) and the pesticide use profile defines those PAU's (for a defined geographic unit under consideration, e.g., county, multi-county, state, multi-state) to be further studied in Step Two of the ranking procedure.

The rating for a particular misuse and a particular health and environmental effect (i.e., Step Two) provides a score (i.e., rating) indicating the likelihood and magnitude of a certain misuse occurring and causing exposure to a certain entity resulting in effects of a certain severity. This rating is made relative to other misuses occurring and causing exposure to other entities of a certain severity. Three concepts are incorporated: the likelihood and magnitude of a particular misuse event; the likelihood that particular non-target entities (human, animal and non-living) are exposed; and the relative severity of damages to the non-target entity from exposure. The first two concepts utilize subjective judgment techniques and require best estimates from people knowledgeable of the PAU under review. The last concept utilizes acute and subacute toxicity data to determine the relative severity of effects to different entities from exposure to different pesticides.

The final step in the ranking procedure provides guidance for interpreting the rating scores in different misuse-entity pairs, both within a particular PAU and between PAU's. That is, various ideas for ranking the misuses within and between PAU's are suggested.

Throughout the entire ranking procedure, in no instance do the procedures require actual data on pesticide misuse and/or health and environmental effects from pesticide misuse (although such data should be used if available). This constraint is consistent with the purpose of the procedure, i.e., to provide a method for anticipating where potential pesticide misuses may be most severe in terms of expected health and environmental damages so that guidance can be provided for selecting particular pesticide misuses for actual monitoring.

STEP ONE - DEVELOPMENT OF A PESTICIDE USE PROFILE

Introduction

Pest control is an integral part of a total agricultural business, commercial process or technological system. From the biological view, a pest is part of an ecosystem ultimately delineated only by finite boundaries of the earth. However, for practical purposes, the ecosystem in question may be considered to be much smaller, consisting of crop fields, home lawns, a watershed, or an industrial building. In addition to a biological environment, pest control takes place at a technological, economic, and sociologic interface where the ultimate pesticide use decision often results from a series of compromises.

Therefore, for regulatory programs to be effective in spotting potential pesticide misuse problems, the total environment in which pest control and pesticide use is practiced must be taken into account. Information gathering and knowledge on the part of regulatory personnel must be comprehensive since a common complaint voiced against regulators is their alleged ignorance of the industry, process, or situation they are designed to regulate.

Consequently, in order to rank the various types of potential pesticide misuse in a given geographical area in terms of their health or environmental impacts, it is essential to first have an in depth understanding of the pest control situation and the pesticide usage for the given geographic area under study. That is, in order to be successful in anticipating where the critical potential pesticide misuses may be, it is necessary to know what the pest problems are, where they are situated, what pesticides (or other means of control) are used to control the problem, how they are used, why they are used, and by whom. In essence, a pesticide use profile for the given geographic area is needed in order to provide a basis for evaluating and ranking potential pesticide misuses in terms of their expected damage to human health or the environment.

Delineating Pesticide/Applicator/Use Situations

In developing a pesticide use profile for a given geographic area, an overview of the pest control situation should be made by delineating the following:

- The prevalent target pest problems in the area;
- The crops and other sites where each pest problem exists;
- The pesticides that are used at each site for each pest problem (e.g., including registered pesticides as well as non-registered pesticides); and
- The types of applicators that apply the pesticide at each site.

The prevalent target pest problems could be from any one of the following general categories of pests:

- Plant pathogens: Organisms which have adverse effects on valuable plants, these effects being called "diseases";
- Weeds: Plants which are unwanted and which compete with valuable plants for water, nutrients, and other life-components;
- Insects and anthropods: Animals which feed upon or otherwise antagonize and damage plants, animals, people, natural and man-made objects, and structures; and

- Vertebrates: Animals which have the same effects in general as the insects and other anthropods.

Moreover, the problem pests could be found in any of a variety of locations or sites, e.g.:

- Non-agricultural locations
  - households and homes;
  - home gardens and household grounds (e.g., lawns, trees, flowers, other ornamentals, etc.);
  - commercial-industrial locations both indoors and outdoors (e.g., factory buildings, food service establishments, hotels, utility, railroad and highway rights of way, golf courses, trees, turfgrass, landscapes, ornamentals, etc.);
  - institutional locations, both indoors and outdoors (e.g., inside buildings and in their outside surroundings);
  - government (federal, state, local) operated locations, both indoors and outdoors (e.g., inside buildings and in their outside surroundings, outdoor recreational facilities - parks and golf courses, etc.);

- Agricultural locations
  - food crop production
  - feed crop production
  - fiber crop production
  - animal production; and
  - food storage and commodity processing locations.

Furthermore, the pesticides used at any site for a particular pest problem could be from any one of the pesticide classes outlined in Exhibit 3. In other words, the pesticides used can be for a variety of purposes, e.g.:

- <u>Pesticide use in food, feed, and fiber production</u>: to include such items as crop production, animal production, cotton, forest products, and all other crops and commodities including storing, processing and consumption of these commodities;

- <u>Pesticide use in health/disease vector and nuisance pest control</u>: to include such items as mosquito abatement, household pests, rabies vectors, ants in lawns, caterpillars in a resort community;

- Pesticide use in commercial-industrial situations: to include utility and highway rights-of-way, oil tank farms and industrial sites, factory buildings, structural pests in wood, in commercial and home situations;

- Pesticide use in providing aesthetic improvement: to include shade trees, turfgrass, golf courses, home lawns and flowers and all vegetation where appearance is the criterion of quality measurement such as in a resort landscape; and

- Pesticide use in providing environmental management: to include fishery resource regulation (i.e., lamprey eel), forest pests where ecosystem balance is deemed essential, and all other uses where environmental quality and ecological considerations are the overriding basis for pesticide use.

Finally, pesticide applicators may be categorized by using the Taxonomy of Applicator/Application Types shown in Exhibit 4.

Selecting Pesticide/Applicator/Use Situations for Further Study

Once all the PAU's* for the given geographic area are delineated in a qualitative sense, further analysis of both a qualitative and quantative nature is in order. This additional analysis can quickly become a massive data gathering effort unless the pesticide use profile preparation can then be restricted to only those situations where potential misuse problems are apparent, are likely to be most prevalent, or are likely to be the most damaging if they occur. Comprehensive knowledge of pest control science and technology should allow the misuse investigator to restrict the pesticide use profile preparation in such a manner so that serious pesticide misuse problem solving can occur.

Different criteria may be used in reaching a decision of how and where to restrict the pesticide use profile. Some of these may be considered unbiased criteria, that is to say, the decision to restrict the pesticide use profile is made without special in depth knowledge of the situation. Others can be based on unique, in depth, or imtimate knowledge and the biases that such knowledge imposes on the pesticide use profile choice. A few examples of unbiased and biased criteria are given below:

- Unbiased Criteria
  - pesticide usage (i.e., pounds sold);
  - size of the applicator group;

*Note that a PAU is strictly defined by one pesticide, one applicator type and one site and pest. For example, if two different types of applicators apply the same pesticide at the same type of site for the same type of pest, this would constitute two PAU's.

- .. scale of target pest situation (e.g., major or minor pests?);
- .. degree of hazard associated with pesticide or use in question (e.g., innate toxicity of pesticide, restricted or general use pesticide?);

- Biased Criteria
  - .. newly registered highly toxic pesticide with little use experience -(i.e., high chance for misuse and resultant damage under such conditions);
  - .. pesticides with changed use pattern, especially more restrictive labeling which users may not be aware of, or willing to accept;
  - .. special restrictions in pesticide use which would tend to be circumvented;
  - .. pesticides where misuse would be perceived by particular users to be to their short term benefit (e.g., more effective if higher dosage, more effective if closer to harvest or slaughter, more effective if on different plant or animal part);
  - .. previous pesticide damage episodes (e.g., human poisoning, crop or animal damage, environmental damage);
  - .. unique deficiencies on the part of particular user groups (e.g., education, experience, financial resources, etc.); and
  - .. deficiencies on the part of the pesticide label which could lead to misuse.

In applying these criteria, the misuse investigator may find that the pesticide use profile should include, for the various reasons cited above:

- Particular pesticides, regardless of their use or who applies them;

- Particular pest control problems (e.g., particular target pests or application sites) regardless of the pesticides used or who applies them; and

- Particular types of applicators, regardless of what pesticides they apply or where they apply them.,

These factors should then be included when selecting the PAU's for further analysis.

Delineating the Characteristics of a Pesticide/Applicator/Use Situation

Once the pesticide use profile is restricted to those PAU's of optimal importance vis-a-vis potential pesticide misuse and its potential effects, a more detailed picture of each PAU should be developed in both a qualitative sense, if possible. Included should be:

- The extent of the pest problem
  - seasonality;
  - major or minor pest;

- Characteristics of the application site
  - size (in acres, homes treated, animals treated, or other appropriate units);
  - geographic surroundings of the application site (e.g., non-target entities physically in the vicinity of the application site);

- Number of pounds of the pesticide used over a one year time period for the pest problem;

- Characteristics of the applicator
  - number of applicators applying the pesticide;
  - educational levels;
  - personal or family income;

- Types of applicator practices used
  - ground application with manual equipment, ground application with non-manual equipment, and/or aerial application;
  - rate and frequency of applications;
  - transport, mixing, loading, storage, and disposal practices;

- The technology of the production system or control situation
  - non-chemical means of control (e.g., biological control, cultural control, physical or mechanical control, or genetic resistance, tolerance or immunity of host plant, crop or other organism);
  - crop rotation and tillage practices;

- Economic incentives underlying the use of the pesticide; and

- Known pesticide damage episodes (if possible)
  - human poisoning;
  - crop and livestock damage; and
  - environmental damage.

Defining the Geographical Area for the Pesticide Use Profile

In defining a geographical area on which to focus such a pesticide use profile, a number of bases may be used, e.g., political regions, commercial-industrial geographic areas, agricultural geographic areas, pesticide enforcement administrative regions, etc. However, to be of most use to the regulatory personnel charged with administering the FIFRA, as amended, a pesticide enforcement administrative region representing the smallest enforcement area of the regulatory agency preparing the pesticide use profile, may be appropriate. For example, if the Federal EPA were preparing a use profile, then the Federal regions may be used to define the geographic boundaries of a profile. If a state pesticide agency were preparing the profile, then each of the state's regions (probably multi-county in character) could be used to define the scope of the profile. All things equal, the smaller the geographic area covered by the pesticide use profile, the greater its precision. In a like manner, the more specific the type of pesticide uses to be studied, the greater the precision that may be anticipated. For example, a pesticide use profile developed for one rural county with one intensive form of agriculture (for example, cotton production), is likely to be far more accurate than a pesticide use profile for a county of rural, urban, and suburban makeup with many agricultural enterprises and pest control problems.

Data Sources for the Pesticide Use Profile

Sources of information on pesticide science and technology, including the agricultural, industrial, aesthetic, commercial, or environmental framework of the use situation, are readily available to aid in the development **of** pesticide use profiles, e.g.,

- Governmental and commercial data gathering services
  - Agricultural Census;
  - State and Federal crop reporting services;
  - Doane Agricultural Service;
  - Trade association inventories;

- Governmental reporting requirements under FIFRA
  - EPA records requirements;
  - EPA requirements for applicator certification programs;
  - State agency dealer sales records, pesticide use reports, etc.;

- Trade publications (e.g., Agricultural Chemicals, Weeds, Trees and Turf, Farm Technology, American Fruit Grower);

- Trade association meetings (e.g., National Pest Control Association, National Agricultural Aviators Association, similar state associations);

- Educational conferences and short courses sponsored by the Cooperative Extension Service;

- Scientific and technological society meetings and publications (e.g., Weed Science, Phytopathology, Economic Entomology);

- Pesticide manufacturers and formulators
  - Technical data published on products;
  - Pesticide labels;
  - Sales meetings;

- Pesticide dealer meetings;
- Technical books (e.g., Thomson Publications -- pesticide series);
- Federal Agency releases; and
- Face to face visitation
  - Extension and research personnel;
  - Professional scouts;
  - Professional pesticide applicators;
  - Pesticide dealers; and
  - Agricultural producers.

STEP TWO - DEVELOPMENT OF A RATING FOR PESTICIDE MISUSES AND ASSOCIATED HEALTH AND ENVIRONMENTAL EFFECTS

Background

The purpose of this step in the ranking procedure is to provide an approach for rating the likelihood and magnitude (i.e., extensity) of various kinds of misuse and the associated severity of health and environmental damages. This process can be viewed as a set of three events:

- The release of pesticides not according to the label (i.e., misuse);
- The impingement or exposure of these pesticides on human beings and other entities in the environment; and
- The occurrence of damages due to this impingement.

Moreover, it should be noted that although exposure cannot occur without release, and similarly, damage cannot occur without exposure* the three events are, nevertheless, "independent" in the sense that the mechanisms causing misuse, exposure and damages to occur are very different for each event. That is, knowing that misuse has occurred does not necessarily mean that exposure will occur and, knowing that exposure has occurred does not necessarily mean that damage will occur. More specifically, misuse is typically a series of human responses to pests, involving many interactions among people, and interactions of people with the environment. Exposure of animals and people to pesticides, however, is a more diverse event in that many natural events -- e.g., rainfall,

*To be more precise, exposure can result from both the proper release of pesticides (i.e., use consistent with the label) as well as from the improper release of pesticides (i.e., use inconsistent with the label). Moreover, one interpretation is that, currently, due to label deficiencies, exposure can be sufficient to cause damage even when pesticides are used according to the label. However, the intent of FIFRA is that as pesticides are re-registered, the label must contain sufficient instructions and precautions so that damage would only occur from exposure resulting from use inconsistent with the label (i.e., misuse).

streamflow, wind, etc. -- are involved, and they act independently of the misuse conditions. Similarly, damages are more related to the biological nature of the organisms suffering these damages, rather than to the human and natural events of misuse and exposure.

In addition, knowing that each of these events has a certain likelihood of occurring is not sufficient for determining the magnitude of the exposure or damage, i.e., how many of a particular entity are exposed (and at what level), how many are damaged by the exposure, and the severity of the damage. These determinations, however, are not easily made since they involve knowing many details about the misused pesticide for a specified period of time, e.g.:

- The number of misuse occurrences, the amount released with each misuse, and the duration of each misuse;
- The location of the misuse occurrences and the non-target entities (kind and amount) in the vicinity of the misuse occurrences; and
- The exposure level to the non-target entities in terms of both amount exposed to and duration of exposure.

Nevertheless, certain information (which may be available or which can be estimated with some confidence) will show the relative magnitude of misuse, resultant exposure, and resultant damage. Specifically, information concerning the number of pounds of the pesticide that are used for a given PAU and the number of applicators associated therewith should be estimated as part of Step One in the ranking procedure. This information, coupled with estimates of the percent of "misapplications" (i.e., the percent of applicators that may misuse pesticides and the percent of pounds applied that may be improperly applied) will give an indication of magnitude of misuse. Furthermore, in general, the greater the number of pounds of a pesticide misused and the greater the number of applicators misusing a pesticide, the greater the number of non-target entities likely to be exposed and the greater the level of exposure.* Similarly, the greater the toxicity of a pesticide to an entity (animal, person), the greater the likelihood of that entity to be more severely damaged for any given exposure level.

Rating Pesticide Misuses and Associated Health and Environmental Effects

With the above assumptions as a background, it is possible to define for a specified geographic area an expression that would assign a rating to indicate the likelihood (or "probability") and magnitude of misuse M_i occurring and causing entity EN_j to be exposed and incur effect EF_k for a given pesticide/applicator/use situation PAU_z in year t; that is, $P(M_i$ and EN_j and EF_k given $PAU_z)_t$. More specifically:

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*This appears plausible for the same kind of misuse for similar PAU's, but perhaps not so plausible for different kinds of misuse for the same, similar, or different PAU's. Therefore, an "entity exposure factor" is needed as described in the next subsection.

$P(M_i$ and EN_j and EF_k given $PAU_z)_t = P(M_i$ given $PAU_z)_t$ x

$P(EN_j$ given $M_i)$ x $(P(EF_k$ given $EN_j)$

where: $P(M_i$ given $PAU_z)_t$ is a factor indicating the estimated level of misuse M_i that would occur in year t given pesticide/applicator/use situation PAU_z (relative to all other misuses for all PAU's);

$P(EN_j$ given $M_i)$ is a factor indicating the likelihood that entity EN_j would be exposed (regardless of the level of exposure ar the severity of the effect) given that misuse M_i occurred;

$P(EF_k$ given $EN_j)$ is a factor indicating the likelihood that effect EF_k would occur given that entity EN_j was exposed;

M_i is a specific type of misuse from those delineated in the "Taxonomy of Pesticide Misuse" (Exhibit 2);

EN_j is a specific entity that could be exposed from those delineated in the "Taxonomy of Potential Health and Environmental Effects from Pesticide Misuse" (Exhibit 6):

EF_k is a specific effect that could result to the entity from those delineated in the "Taxonomy of Potential Health and Environmental Effects from Pesticide Misuse" (Exhibit 6); and

PAU_z is a defined pesticide/applicator/use (site and pest) situation for a given geographic area in year t as developed through Step One of the ranking procedure (note: it is possible that a defined PAU_z will, by its very nature, be a pesticide misuse, e.g., use of a pesticide on an unregistered application site -- minor use situations are a good example).

Assessing the Likelihood of Specific Misuses--

To calculate $P(M_i$ given $PAU_z)$, two components need to be assessed: 1) the number of pounds misused in way M_i in year t given PAU_z, and 2) the number of applicators misusing the pesticide in year t in way M_i given PAU_z.

Assessing the First Component-- The number of pounds (active ingredient) of the pesticide applied for PAU_z that are misused in way M_i in year t =

$$\left(\begin{array}{l}\text{total pounds (a.i.) of}\\ \text{the pesticide applied}\\ \text{for } PAU_z \text{ in year t}\end{array}\right) \times \left(\begin{array}{l}\text{percent of total pounds (a.i.)}\\ \text{applied for } PAU_z \text{ that are mis-}\\ \text{used in way } M_i \text{ in year t}\end{array}\right)$$

The expression in the first parentheses would have been determined or estimated in Step One of the ranking procedure via pesticide dealer records, pesticide use reports, etc.

The expression in the second parentheses can be determined if sufficient data collection by pesticide inspectors has occurred in the geographic area in question over a year's time <u>or</u> by asking knowledgeable people the following question: <u>For PAU_z, what amount of the total pounds (a.i.) of the pesticide applied in year t would you expect to be misused in way M_i</u>? Their responses can be a choice from the following subjective rating scale:

	Corresponding percentages that could be associated with response (probabilities)
1. None (by definition of M_i and the given PAU_z)	0.0% (0.000)
2. Almost none	12.5% (0.125)
3. Much less than half	25.0% (0.250)
4. Less than half	37.5% (0.375)
5. About half	50.0% (0.500)
6. More than half	62.5% (0.625)
7. Much more than half	75.0% (0.750)
8. Almost all	87.5% (0.875)
9. All (by definition of M_i and the given PAU_z)	100.0% (1.000)

In making this subjective assessment, guidance can be provided to the respondent regarding those factors of the PAU that are of importance (some are from the pesticide use profile), e.g.:

- Knowledge of the applicator vis-a-vis the proper handling and use of pesticides;
- Typical application practices of the applicator (e.g., transport, mixing, loading, storage, application, and disposal practices);
- Geographic surroundings where the application takes place (e.g., are there lakes and streams nearby?);
- The efficacy of the pesticide vis-a-vis pest problems in the geographic are;
- Institutional constraints (e.g., disposal facilities for used containers);
- Applicator constraints: and
- Self-interests of applicator, i.e., economic incentives.

Assessing the Second Component-- The number of applicators applying the pesticide for PAU_z that misuse the pesticide in way M_i in year t =

$$\left(\begin{array}{l}\text{total number of}\\ \text{applicators for}\\ PAU_z \text{ in year t}\end{array}\right) \times \left(\begin{array}{l}\text{percent of total number}\\ \text{of applicators that would}\\ \text{misuse the pesticide in}\\ \text{way } M_i \text{ in year t}\end{array}\right)$$

The expression in the first parentheses would have been determined or estimated in Step One of the ranking procedure via the number of licenses issued, enforcement agency data, extension service information, etc.

The expression in the second parentheses can be determined in a similar fashion as the percent of total pounds applied for PAU_z that are misused in way M_i. If data were not available for a one-year time period, the knowledgeable person could be asked the following question: For PAU_z, what number of the total number of applicators applying the pesticide in year t would you expect to misuse the pesticide in way M_i? His response can be a choice from the rating scale described on the previous page.

Combining the Two Components to Determine a Value of $P(M_i \text{ given } PAU_z)_t$ -- Since it has been assumed that the relative magnitude of a misuse M_i is dependent upon both the number of pounds misused in way M_i and the number of applicators misusing the pesticide in way M_i, the value for $P(M_i \text{ given } PAU_z)_t$ can be represented by the product of the two components (see Exhibit 8). This would say, for example, that if the pounds misused for M_1 were twice those misused for M_2, but the number of applicators were the same, the relative magnitude of M_1 would be twice that of M_2.

Assessing the Likelihood of Exposure from Pesticide Misuse--

To calculate the second factor, $P(EN_j \text{ given } M_i)$, a two dimensional matrix (with entities exposed as one dimension and misuses as the other dimension) can be developed based on the misuse taxonomy and the entities delineated in the health and environmental effects taxonomy (see Exhibit 9). Then, for a given PAU_z, the knowledgeable person could be asked the following question: Given PAU_z, if a pesticide is misused in way M_i (i.e., "x" number of applicators misuse "y" pounds), how likely is it to reach entity EN_j, regardless of the level of exposure or the severity of the effect? His response could be a choice from the following subjective rating scale:

Exhibit 8: Assessment of the Likelihood and Magnitude of Specific Misuses for a Given Pesticide/Applicator/Use Situation (PAU_z)

	PAU_z					
Misuse M_i	total pounds (a.i.) applied for PAU_z in year t (1)	percent of total pounds applied misused in way M_i (2)	number of pounds (a.i.) misused in way M_i (3) = (1) x (2)	percent of total number of applicators misusing pesticide in way M_i (5)	number of applicators misusing pesticide in way M_i (6) = (4) x (5)	$P(M_i$ given $PAU_z)_t$ (7) = (3) x (6)
Type 1 Misuse - Applicator Certification						
Type 2 Misuse - Application Site						
Type 3 Misuse - Target Pest						
Type 4 Misuse - Dosage Rates						
Type 5 Misuse - Frequency or Timing of Applications						
Type 6 Misuse - Application Equipment/ Formulation						
Type 7 Misuse - Protective Clothing						
Type 8 Misuse Re-entry						
Type 9 Misuse - Use Procedures/ Restrictions						
Type 10 Misuse - Storage or Disposal						

Exhibit 9: Assessment of the Likelihood of Entities Exposed from Pesticide Misuses for a Given PAU_z

	PAU_z												
Entities Exposed EN_j / Misuse M_i	Human Beings								Domestic Animals		Wildlife	Soils, Agricultural Commodities Crops, Plantlife	Non-Living Structures
	Occupational				Non-Occupational								
	skin	eyes	respiratory tract	mouth	skin	eyes	respiratory tract	mouth	farm animals	household pets			
Type 1 Misuse - Applicator Certification													
Type 2 Misuse - Application Site													
Type 3 Misuse - Target Pest													
Type 4 Misuse - Dosage Rates													
Type 5 Misuse - Frequency or Timing of Applications													
Type 6 Misuse - Application Equipment/ Formulation													
Type 7 Misuse - Protective Clothing													
Type 8 Misuse - Re-entry													
Type 9 Misuse - Use Procedures/ Restrictions													
Type 10 Misuse - Storage or Disposal													

Note: Answering the question posed in this section will provide an assessment for <u>one</u> cell of this matrix. Thus, to fill in the entire matrix the question must be asked n x m times where n = the number of different M_i's delineated and m = the number of different EN_j's delineated. Both the misuses delineated and the entities delineated can be broken down in more detail, if desired, as is done in the taxonomies of misuse and health and environmental effects.

	Corresponding probabilities that could be associated with response
1. Could not happen (by definition Of M_i and EN_j)	0.000
2. Could almost never happen	0.125
3. Very unlikely	0.250
4. Unlikely	0.375
5. Can't say (50-50 chance)	0.500
6. Likely	0.625
7. Very likely	0.750
8. Almost certain to happen	0.875
9. Would definitely happen (by definition of M_i and EN_j)	1.000

In making such an assessment, guidelines can be provided to the responder vis-a-vis those factors that have an influence, e.g.:

1. The type of misuse in question;
2. Geographic surroundings where the application and misuse would take place;
3. Application technique utilized, including the rate and frequency of application;
4. Non-target entities in the vicinity of the application site;
5. General chemistry data
   A. explosive characteristics of the pesticide formulation;
   B. stability of the active ingredient;
6. Environmental chemistry data (if an outdoor application site)
   A. pesticide fate and movement in soils
      1. edaphic, soil and climatic descriptions
         a. soil classifications using USDA classes;
         b. physical and chemical properties of soil surface;
      2. soil metabolism studies
         a. degradation studies -- rate, type, and degree for parent product and for its transformation products;
         b. soil residue studies
            i. dissipation rate;
            ii. accumulation rate;
      3. soil persistence studies;
      4. leaching studies;
      5. lateral movements in soils;
   B. pesticide fate and movement in water
      1. dissipation rate in distilled water;
      2. degradation in water containing suspended solids;
      3. degradation studies in bottom sediments;

4. translocation studies;
5. livestock and poultry drinking water studies;
6. tests involving moving water;

C. pesticide residue studies
1. fish and wildlife studies;
2. crop uptake studies;

D. photodegradation studies;

E. volatization studies;

F. microbiological studies
1. effect of pesticides on microorganisms; and
2. effect of microorganisms on pesticides.

Assessing Associated Health and Environmental Effects--

In calculating the third and last factor, P(EF_k given EN_j), the question one wants to pose to the knowledgeable person is the following? <u>Given PAU_z, how likely is it that entity EN_j would incur effect EF_k assuming entity EN_j was exposed to misuse M_i</u>? His response could be a choice from the rating scale utilized to assess P(EN_j given M_i), i.e., see page 42. However, in making such an assessment, the respondent will have to have more information than simply "entity EN_j was exposed to misuse M_i". For instance, he will need to know, among other things, the level of exposure, both in terms of the amount exposed to and the duration of the exposure. As indicated previously, these determinations are probably not possible.

Nevertheless, there are available data for non-target organisms that allows one to compare the <u>inherent toxicity</u> of different chemicals for different non-target entities and, hence, the relative severity of an effect for different non-target organisms and pesticides given the same exposure level. The data referred to are acute toxicity data expressed by means of an LD_{50} value (i.e., a statistical estimate of the dosage that would be lethal to 50 percent of a very large population of the test species).

Therefore, if one were to take the inverse of the LD_{50} value for a specific pesticide and test species (i.e., non-target entities), the resultant number would provide a measure of the severity of the effect to that entity from that pesticide, <u>relative to</u> the severity of an effect from other pesticides and/or to other entities. A difficulty in this approach is that the likelihood of each of the particular effects to each entity outlined in the taxonomy of health. and environmental effects would <u>not</u> be determined; rather the relative severity of the effect would be assessed. However, to date, this method appears to be the best way to assess the relative severity of damage that could be caused to different entities EN_j from different misuses M_i arising from different PAU_z's. Moreover, this toxicity data must accompany pesticide product registration requests and thus should be readily available. The sections below further develop the use of this toxicity data.

<u>Human Health Effects--</u> If the entity exposed is expected to be human beings, both occupational and non-occupational health effects can occur via one or more of the following routes of exposure: eyes, skin, mouth, and respiratory tract. Methods to assess the severity of health effects from each route of exposure are presented below.

. Exposure Route - Eyes-- Based on the acute primary eye irritation test on the rabbit, the pesticide product will fall into one of the four toxicity categories as outlined in 40 CFR 162.10 of the Federal regulations:

1. Toxicity category I - corrosive, corneal opacity not reversible within seven days;
2. Toxicity category II - corneal opacity reversible within seven days, irritation persisting for seven days;
3. Toxicity category III - no corneal opacity, irritation reversible within seven days; or
4. Toxicity category IV - no irritation.

If the pesticide product falls into toxicity category I, a severity value of 1.0 can be assigned; if toxicity category II, a severity value of 0.09 can be assigned; if toxicity category III, a severity value of 0.009 can be assigned; and if toxicity category IV, a severity value of 0.005 can be assigned.*

. Exposure Route - Skin-- Utilizing dermal LD_{50}'s (expressed in mg/kg body weight) the relative severity of the following two types can be assessed:

1. Acute or subacute effects (i.e., morbidity - acute or subacute minor, acute and subacute major; mortality - immediate) - assess by determining 100** ÷ the rabbit acute dermal LD_{50} of the pesticide, in the solvent and at the concentration associated with Mi and PAU_z; and

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*These values were derived so that the resulting severity measure from ocular exposure would be equivalent to the severity measure determined for a "likely" dermal LD_{50} in the same toxicity category, as defined in the "Toxicity Categories" tabulation in 40 CFR 162.10, i.e., for toxicity category I, a dermal LD_{50} of 100 mg/kg; for toxicity category II, 1,100 mg/kg; for toxicity category III, 11,000 mg/kg; and for toxicity category IV, 20,000 mg/kg.

**Rather than simply taking the inverse of LD_{50}, a safety factor of 100 is also utilized. There is worldwide acceptance of the arbitrary "factor of safety" of 100 which was first proposed by A.J. Lehman of the Food and Drug Administration for dealing with new substances to which the human race has not yet been exposed extensively, and was published in the Federal Register of March 11, 1955 (p. 1493). It is now applied to all substances as a conservative factor between animal experiment and human tolerance, except when a lower factor may be justified because it is known that the system injured by the substance responds nearly equally in different species, such as cholinesterase or corneal injury. It is quite obvious that the number 100 may be too high for some substances and too low for others. The only way to get a more defensible number is to determine the relative resistance of the target system to the substance or, almost as good, select an experimental species which biotransforms the substance qualitatively and quantitatively like the human.

2. Chronic effects (i.e., morbidity - chronic minor or major; mortality - delayed) - assess by determining 100 ÷ the rabbit subacute dermal LD_{50} of the pesticide, in the solvent and at the concentration associated with Mi and PAU_z.

• Exposure Route - Mouth-- Utilizing oral LD_{50}'s (expressed in mg/kg body weight), the relative severity of the following two types of effects can be assessed:

1. Acute or subacute effects - assess by determining 100 ÷ the rate acute oral LD_{50} of the pesticide, in the solvent and the concentration associated with Mi and PAU_z; and

2. Chronic effects - assess by determining 100 ÷ the rat subacute oral LD_{50} of the pesticide, in the solvent and at the concentration associated with Mi and PAU_z.

• Exposure Route - Respiratory Tract-- Utilizing inhalation LC_{50}'s (expressed in mg/liter of air), the relative severity of the following two types of effects can be assessed:

1. Acute or subacute effects - assess by determining 0.4* ÷ the rat acute inhalation LC_{50} of the pesticide, in the solvent and at the concentration associated with Mi and PAU_z; and

2. Chronic effects - assess by determining 0.4 ÷ the rat subacute inhalation LC_{50} of the pesticide, in the solvent and at the concentration association with Mi and PAU_z.

Environmental Effects-- If the entity exposed from pesticide misuse is expected to be non-human or non-living, environmental effects can result. The severity of the effects can be assessed for each entity as described below.

• Domestic Animals -- Utilizing oral LD_{50}'s and/or dermal LD_{50}'s (as expressed above), the relative severity of the following two types of effects can be assessed:

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*This number was derived so that the resulting severity measure from oral exposure or inhalation exposure would be equivalent for an oral LD_{50} and an inhalation LC_{50} that are equally toxic according to the "Toxicity Categories" tabulation in 40 CFR 162.10.

1. Acute or subacute effects (i.e., morbidity - acute, subacute; morbidity - immediate) - assess by determining the inverse of either the acute oral LD_{50}, the acute inhalation LC_{50}, or the acute dermal LD_{50} (depending upon the most likely route of exposure given the M_i, EN_j, and PAU_z in question), utilizing the LD_{50} or LC_{50} of the pesticide, in the solvent and at the concentration associated with M_i and PAU_z, and for the entity EN_j in question or for an appropriate species; and

2. Chronic effects (i.e., chronic morbidity or delayed mortality) - assess by determining the inverse of either the subacute oral LD_{50} the subacute inhalation LC_{50}, or the subacute dermal LD_{50} (depending upon the most likely route of exposure given the M_i, EN_j, and PAU_z in question), utilizing the LD_{50} or LC_{50} of the pesticide, in the solvent and at the concentration associated with M_i and PAU_z, and for the entity EN_j in question or for an appropriate species.

. Wildlife - Mammals-- Utilizing oral LD_{50}'s, inhalation LC_{50}'s and/or dermal LD_{50}'s, the relative severity of the following two types of effects can be assessed:

1. Acute or subacute effects - assess by determining the inverse of either the acute rat oral LD_{50}, the acute rat inhalation LC_{50}, or the acute rabbit dermal LD_{50} (depending upon the most likely route of exposure given the M_i, EN_j, and PAU_z in question), utilizing the LD_{50} or LC_{50} of the pesticide, in the solvent and at the concentration associated with M_i and PAU_z; and

2. Chronic effects - assess by determining the inverse of either the subacute rat oral LD_{50}, the subacute rat inhalation LC_{50}, or the subacute rabbit dermal LD_{50} (depending upon the most likely route of exposure given the M_i, EN_j, and PAU_z in question), utilizing the LD_{50} or LC_{50} of the pesticide, in the solvent and at the concentration associated with Mi and PAU_z.

. Wildlife - Birds, Fish and Reptiles-- Utilizing oral LD_{50}'s or subacute dietary LC_{50}'s, the relative severity of the following two types of effects can be assessed:

1. Acute or subacute effects - assess by determining the inverse of the acute oral LD_{50} of the pesticide, in the solvent and at the concentration associated with M_i and PAU_z, for either a wild waterfowl species or an upland game bird species for birds, and for either rainbow trout or bluegill for fish and reptiles; and

2. Chronic effects - assess by determining the inverse of the subacute dietary LC_{50} of the of the pesticide, in the solvent and at the concentration associated with M_i and PAU_z, for either a wild waterfowl species or an upland game bird species for birds,, and for either rainbow trout or bluegill for fish and reptiles.

. Wildlife - Aquatic Organisms Other Than Fish, and Bees and Other Insects -- Utilizing acute LC_{50}'s, the relative severity of the effect can be assessed by determining the inverse of the acute LC_{50} (96-hour protocol) of the pesticide, in the solvent and at the concentration associated with M_i and PAU_z, for either Daphnia sp. (if for aquatic organisms) or bees (if for bees).

. Soils, Agricultural Commodities, Crops or Plant Life -- For agricultural commodities, crops or plant life, utilizing the phytotoxicity of the pesticide, in the solvent and at the concentration associated with M_i and PAU_z, the relative severity of the effect can be assessed by determining the inverse of the average margin of safety between effective pesticide levels and those which cause chlorosis and death to the crop, agricultural commodity or plant.

For soils, utilizing the persistence of the pesticide in the solvent and at the concentration associated with M_i and PAU_z, the relative severity of the effect can be assessed by determining its half-life in soil (measured in years).

. Non-Living Structures -- The severity of the contamination would be directly related to the likelihood and magnitude of the misuse occurring and the likelihood of exposure to the particular non-living entity. Thus, the relative toxicity of the pesticide would not affect the severity of the contamination to the non-living entity and need not be considered for this exposed entity.

Summarizing Associated Health and Environmental Effects -- As the assessments above are made, they can be summarized in matrix form. Exhibit 10 presents such a matrix.

Exhibit 10: Assessment of the Relative Severity of Health and Environmental Effects to Entities Exposed from Pesticide Misuse for a Given PAU_Z

Entity Exposed EN_j and Relative Severity of Effect / Misuse M_i	PAU_z																							
	Human Beings																Domestic Animals				Wildlife		Soils, Agricultural Commodities, Crops, Plantlife	Non-Living Structures
	Occupational								Non-Occupational															
	skin		eyes		respiratory tract		mouth		skin		eyes		respiratory tract		mouth		Farm Animals		Household Pets					
	A/S	C	A/S	C	A/S	C	A/S	C	A/S	C	A/S	C	A/S	C	A/S	C	A/S	C	A/S	C	A/S	C		
Type 1 Misuse - Applicator Certification																								
Type 2 Misuse - Application Site																								
Tye 3 Misuse - Target Pest																								
Type 4 Misuse - Dosage Rates																								Not
Type 5 Misuse - Frequency or Timing of Applications																								Applicable
Type 6 Misuse - Application Equipment/ Formulation																								
Type 7 Misuse - Protective Clothing																								
Type 8 Misuse - Re-entry																								
Type 9 Misuse - Use Procedures/ Restriction																								
Type 10 Misuse - Storage and Disposal																								

Note: A/S means acute or subacute effects and C means chronic effects. If desired, the misuses delineated and the entities delineated can be broken down in more detail as is done in the taxonomy of pesticide misuse and in the health and environmental effects taxonomy.

Concluding Remarks

The above approach provides a way to rate the likelihood and magnitude of various kinds of misuse and the severity of associated effects. The procedure described focuses on one PAU at a time and would pose questions to knowledgeable people about the likelihood and magnitude of various misuses (M_i's) occurring (i.e., Exhibit 8 would be completed) and the likelihood of various entities (EN_j's) being exposed from each M_i (i.e., Exhibit 9 would be completed). Then, the relative severity of the effect to various EN_j's exposed would be determined based on the acute and subacute toxicity of the pesticide to the entity (i.e., Exhibit 10 would be completed). All three factors would then be multiplied and the results can be presented in a rating score matrix having the same format as Exhibit 10. Each cell will contain, for a particular PAU_z, a rating representing the likelihood and magnitude of a certain misuse occurring and causing exposure to a certain entity resulting in effects of a certain severity, relative to other misuses occurring and causing exposure to other entities of a certain severity.

STEP THREE - INTERPRETATION OF THE RATINGS AND RANKING OF POTENTIAL PESTICIDE MISUSES

As indicated above, three concepts are incorporated in determining the rating of a particular misuse and associated effect for a given PAU, i.e.:

- The occurrence of the misuse;
- The occurrence of exposure to a non-target entity; and
- The occurrence of damages to a non-target entity.

In developing the estimate of a particular misuse occurring, two factors are utilized: the number of pounds misapplied and the number of applicators who misapplied. The interpretation of these factors is simple if the interpreter is familiar with the general range of pesticide amounts applied by particular types of applicators during a season, so that he can comprehend the implications of the pounds misapplied or number of applicators who misapplied. Multiplying the two factors together, as was indicated, will produce a combined score for pounds misused and applicators at fault. The combined score obtained by multiplying the two actual numbers will have units of "pounds-applicators", but interpretation of these values will be simple if the ranges across other misuses, other PAU's or other geographic areas are known. In other words, even though the concept of "pounds-applicators" is difficult, the index will be meaningful by comparison.

In developing the estimate of exposure, a subjective rating technique is used which enables knowledgeable people to produce a reliable and probably a valid estimate. This estimate is defined as the probability of one organism in a given sub-population being exposed to (coming in contact with) a pesticide which has been released improperly. These judgments will be decimals or percents, and they will reflect the likelihood that the pesticide will come into contact with a specified non-target entity.

In developing the estimate of damages, the inverse of the pesticide's toxicity to a given entity is used (i.e., one divided by the pesticides's LD_{50} for a given entity). In this way, a measure is obtained of the relative severity of damages to a given entity from exposure to a given pesticide. That is, the more toxic the pesticide is, the lower the LD_{50} is and, hence the larger the inverse is.

The overall rating score for a particular misuse and associated effect is obtained by multiplying these three concepts together, i.e.,

Pesticide Misuse Rating Score = Misuse (pounds-applicator) x

Exposure (Probability) x Severity of Damage (1 ÷ mg. per kg.).

This final rating score will be very large if the expected severity of a pesticide misuse is large. That is, the higher the value of the rating score, the greater the misuse of the pesticide, the greater the exposure and/or the more severe the damages from misuse. Basically then, the rating score is an environmental indicator giving some indication of where, and how environmental damages occur from misuse. As noted previously, the rating score will be useful only as a relative score, and data generated from the rating effort will also be needed to make interpretations. These data can be classified on four dimensions:

- Pesticide/applicator/use situation (PAU) and its characteristics;
- Geographic unit associated with the PAU;
- Type of misuse; and
- Entity (species) exposed.

Therefore, the rating score matrix, similar in format to Exhibit 10, with types of misuse as row labels and types of organisms exposed and severity of effect as column headings, will actually be available from many PAU's and many geographic units. If desirable, the values in these matrices can be averaged (across PAU's for the same geographic unit or across geographic units for the same PAU or across both dimensions) to form a single rating score matrix which will enable direct inspection of the magnitude and severity of misuse effects for the series of entities shown in the column headings. Moreover, this matrix (or a matrix for an individual PAU and geographic unit) can be reduced by averaging the values in each row to produce a single vector of severities for the types of misuse. This vector will be a column of values showing the relative severities of each of the ten major types of misuse or possible sub-categories within these major types, as shown in the misuse taxonomy.* Finally, a simple ranking of misuses, from the highest rating score to the lowest rating score, can be done, if desirable, and should provide valuable insight into where further study of pesticide misuse should begin.

*Notations for the values generated by these manipulations of the rating scores would be necessary and could be easily developed.

The determination of (or insights into) the motivational and behavioral components of misuse do not automatically emerge from interpreting the ratings and ranking pesticide misuse types. The inquiry into how various misuse events occur is only partly delineated, or hinted at, by identification of the intended use and the amount of pesticide dispersed by misuse. The next step, thus, would be to study (e.g., monitor) the various types of misuse with respect to severity (see Chapter 4) and the behavioral features of the misuse event (see Chapter 5). This type of analysis could eventually lead to the formulation of compliance strategies as well (see Chapter 6).

SUMMARY

The procedure for ranking the severity of potential pesticide misuse is intended to provide a basis for further action so that environmental and human health damages from pesticide misuses can be lessened. This reduction of damages will be achieved by reducing misuse of pesticides, and particularly by reducing those types of misuse which lead to more severe environmental and human health damages.

Therefore, the ranking scheme is designed to enable the misuse investigator to pinpoint the more severe types of misuse (i.e., those resulting in the more severe types of damages). More specifically, a three step procedure has been devised to: 1) define those PAU's for which pesticide misuse ratings should be developed; 2) rate pesticide misuses based upon the likelihood and magnitude of the given misuse occurring and causing exposure to certain entities resulting in effects of a certain severity; and 3) interpret and rank the various types of pesticide misuse based upon a misuse's derived rating for a defined PAU.

The misuse rating score thus defined will be specific for a PAU (and inherently for a geographic area) but could be generalizable to other PAU's with similar values and characteristics. In addition, the rating scores can be compared across PAU's and across geographic units. This will be useful in gaining insight into the more dangerous PAU situations within a region or state.

Theoretically, the procedure could be extended to determine the estimated damage from a misuse, in terms of crops destroyed, fish and wildlife killed, and human illness. But the rating score itself will be useful as an indicator of a misuse's likelihood, magnitude and severity. In addition, the data compiled in the development of the rating scores will be useful in understanding the severity of various types of misuse, and in subsequently developing strategies for their reduction.

Therefore, the derived misuse rating score is a flexible, useful number relevant to assessing the likelihood, magnitude and severity of the misuse. The higher the value of the rating score, the greater the misuse of the pesticide the greater the exposure and/or the more severe the damages from misuse. Moreover, the higher the value of the rating score, the higher the ranking of the pesticide misuse relative to other misuses in terms of expected health and environmental damages.

In conclusion, the reader should note that the ranking procedure (and particularly the development of rating scores) heavily relies on subjective judgments of knowledgeable people. Hence, it would be most advantageous to have <u>many</u> individuals with <u>diverse</u> backgrounds involved in developing each rating <u>score</u> for each PAU. For example, EPA officials, state regulatory officials, toxicologists, biologists, city public works officials, industrial maintenance personnel, and actual users (e.g., commercial pest control operators, farmers, etc.), should all get involved. By doing so, the validity and acceptability of the final score will be enhanced, since the <u>combination</u> of their judgments will be a close approximation to the "true" probabilities of misuse, and subsequent damage. The acquisition of an individual person's judgment can be done by mail or any other convenient way, and the judgments can be anonymous.

Chapter 4

DEVELOPMENT OF A PESTICIDE LABEL ADHERENCE INFORMATION SYSTEM

OVERVIEW

Introduction

The purpose of this chapter is to present a detailed system for measuring adherence with pesticide label requirements, including data collection and filing procedures. The system and accompanying discussion are intended to prove useful to personnel at all levels involved in studying, analyzing, and reducing pesticide misuse, as defined by Section 12(a)(2)(G) of FIFRA, as amended. Thus, the information will be useful to Federal, regional, state and county personnel who have monitoring, review and research requirements, as well as to personnel faced with the immediate task of allocating resources for monitoring and compliance strategies.

Specifically, the Pesticide Label Adherence Information System (PLAINS) described herein is intended to:

- Enable the establishment of a baseline measure of the extent of pesticide misuse and the resultant environmental damages over time; and
- Enable the evaluation of the effectiveness of alternative monitoring and compliance strategies.

These broad objectives of the PLAINS, however, should not disguise the basic purpose of the system which is to produce and accumulate indicators and basic data on pesticide misuse, such as date of misuse, locations, amount of pesticides, type of misuse, severity of damages and factors leading to misuse. The information system will have broad scope for meshing many types of monitoring data and reports, but its essential content will be these practical misuse variables.

To achieve these objectives, the PLAINS will utilize a variety of descriptive and narrative reports as well as statistical data. These reports will include medical reports of health damages and naturalists' reports of environmental damages. The PLAINS must use these various types of information and integrate them with the basic statistical measures such as pesticide dispersion and toxicity.

The sources of all of these types of input data will be from the following categories:

- Existing data systems containing basic data on pesticides; e.g., the Pesticides Analysis Retrieval and Control System (PARCS);

- Existing use monitoring systems, such as routine use inspection programs and review of pesticide usage reports;

- Existing misuse monitoring systems, such as misuse investigations and other Federal, state, and local activities;

- Existing pesticide episode reporting systems such as Pesticides Abstracts and Pesticide Episode Reporting System (PERS);

- Existing residue monitoring systems, such as USDA/APHIS, Pesticides Monitoring Journal and STORET; and

- Special data generating activities contained in the PLAINS.

The above list of categories is overlapping, but it gives a picture of the scope of information sources, i.e., inputs, for the PLAINS.

The important aspect of having this broad range of inputs, and integrating them, is that the PLAINS data can be used to validate models developed for estimating the types and factors leading to misuse, and the severity of damages which will probably result. These measures will show the level of label adherence and the extent of misuse.

Component Techniques of the PLAINS

The basis for the development of this integrated procedure has evolved from various component procedures and techniques already developed and utilized within Federal EPA agencies, and within several states. Therefore, the PLAINS procedure is intended to complement, as well as supplement the existing activities and provide a more systematic and comprehensive quantifying and coding process for use in compiling a misuse data base, and for analyzing the level of label adherence and the extent of misuse.

More specifically, the integration is achieved by using four component techniques and by matching dates and locations of data inputs, to make direct connections between misuses of various types, causes, and severity. The four component techniques approach the misuse measurement problem directly and provide measures of misuse immediately. Overall, the component techniques will include:

- Pesticide use observation;

- Pesticide user audit;

- Monitoring reports of health and environmental damage alleged to be caused by pesticides; and

- Monitoring pesticide residues.

The structure of each of these component techniques for misuse measurement must be comprehensive and must address the following features:

- How misuse is detected, i.e, is it known that a label violation has occurred?

- Data requirements necessary for assessing the "extent of misuse" (e.g., the type of misuse, the severity of damages, the frequency of occurrence, and the factors leading to the misue), i.e., what measurements must be obtained?

- Methods of data generation, i.e., how will the "extent of misuse" measurements be obtained, what kind of data gathering activities will be necessary, and what information sources will be utilized?

- Data compiling and management procedures, i.e., how should these measurements be recorded, stored and analyzed in order to obtain a baseline measure of misuse and evaluate alternate monitoring and compliance strategies?

- Operational feasibility notes, i.e., How well does the label adherence/extent of misuse measurement component technique fit in with ongoing misuse investigation activities, and overall, with various pesticide/applicator/use contexts?

- Resources costs and analysis, i.e., What are the expected costs of personnel, materials, travel, data management, and record keeping for each proposed measurement component technique?

In other words, each of the proposed component techniques (use observation, pesticide user audit, damage reports, residue reports) must have procedures which enforcement personnel (or others) can use and apply in a given pesticide context.

The procedures for detecting misuse will be different for each of the four measurement methods. For example, for the "user audit", the enforcement official will initially need to make a probabilistic judgment, but since he will not be gathering legal evidence, rules for making such judgments can be practical and feasible. For "use observations", conversely, the misue (if one occurs) is likely to be directly observed, and can be noted for use in developing and implementing compliance strategies.

The data requirements necessary to assess the extent of misuse will be the same for all four component techniques. Exhibit 11 presents an outline of pertinent data requirements that each technique must strive to obtain.

The four component techniques which form the initial core of PLAINS will utilize three basic methods for generating the required data:

- Direct pesticide use observation;
- Compiling and analyzing pesticide use reports and reports from misuse interviews and surveys; and
- Compiling and analyzing remote input data (e.g., residue data and environmental damages data).

In other words, the component techniques will rely on residue data and other remote surveys (e.g., reports from Pesticides Abstracts, PEPS, etc.) to find possible misuse and to assess the level of label adherence. In addition, interviews with physicians, wildlife rangers, and other experts will provide descriptions of misuse events and related damages. Finally, certain data needs will require a limited amount of direct pesticide use observation. Exhibit 12 describes the component techniques which form the core of PLAINS by means of a data input table.

Once data are obtained by each component technique, they will have to be compiled, recorded, stored, and analyzed. Standardized forms should be used wherever possible to record information about misuse cases. This information should then be coded and converted into machine readable form for easy storage and access. This will require that coding schemes be developed and that procedures for converting these codes to machine-readable form be developed. Existing coding schemes and procedures (e.g., those used in the PERS) can be utilized or additional procedures can be developed.

Once the information is in machine-readable form, data analysis will be facilitated because all data generated by these four component techniques will be contained in one central system. Various uni-dimensional frequency tabulations and multi-dimensional cross tabulations can be generated to obtain a picture of pesticide misuse at any point in time. Thus, alternate monitoring and compliance strategies can be evaluated through these data analyses.

Finally, the feasibility and resource cost features for each of the four misuse measurement techniques must be developed and described in order to implement the techniques. These cost/feasibility features are crucial in planning a measurement program which will be cost-effective in terms of contributing to the development and use of compliance strategies.

Particular aspects of each of these misuse measurement component techniques are described in more detail in the remaining sections of this chapter. Data recording, storage, and analysis procedures for all techniques are also further described in a separate section of this chapter.

Exhibit 11: Data Requirements for Assessing the Extent of Misuse

- Date of misuse occurrence;

- Location of misuse occurrence, i.e., City, County, State, Federal region;

- Pesticide/applicator/use situation involved;
  - .. pesticide involved;
    - ... product name, active ingredients, and pesticide class;*
    - ... toxicity data, if available;
    - ... amount dispersed, e.g., dilution rate, application rate of diluted material and active ingredient;
  - .. type of applicator involved.**
  - .. use situation, e.g., site of application (including size) and pest involved;

- Method of use involved, e.g., transport, mixing, loading, application, storage, disposal, etc.;***

- Type of misuse committed;****

- Health or environmental effects, i.e., severity of damages;*****
  - .. type and number killed;
  - .. type and number ill or damaged;
  - .. type and number contaminated and level of contamination;
  - .. dollar value of damage, if given;

- Factors leading to misuse, i.e., cause;****** and

- Additional information, if deemed pertinent.

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*As specified in Taxonomy of Pesticide Classes (Exhibit 3).
**As specified in Taxonomy of Applicator/Application Types (Exhibit 4).
***As specified in Taxonomy of Methods of Use (Exhibit 5).
****As specified in Taxonomy of Pesticide Misuse (Exhibit 2)
*****As specified in Taxonomy of Potential Health and Environmental Effects (Exhibit 6).
******As specified in Taxonomy of Factors Leading to Pesticide Misuse (Exhibit 7).

Exhibit 12: Data Input Table for Component Techniques of PLAINS

Component Technique	Types of Data Used		
	Direct Pesticide Use Observations	Pesticide Use Reports and Misuse Interviews/Surveys	Remote Input Data
Use Observation	X	Y	Z
Pesticide User Audit	Y	X	Z
Damages Monitoring	Z	Y	X
Residue Monitoring	Z	Z	X

Key: X = important source of input
Y = possible source
Z = rarely used

PESTICIDE USE OBSERVATION

Description of the Technique

The use observation misuse measurement technique can best be described as a routine inspection program; that is, it does not assume that a pesticide misuse has occurred. Rather, a cross section of pesticide uses, during or immediately following actual application, are observed, i.e.:

> "The purpose of use inspections is to develop data on the common practices of applying pesticides, to encourage the proper use of pesticides and to determine whether pesticides are being used in accordance with their labeling. This data will enable the Agency to determine whether the users of pesticides:
>
> a. read and understand the labels on the products they purchase and use;
>
> b. follow the directions and precautions on the label;
>
> c. properly clean and maintain application and protective equipment in good working order;
>
> d. properly store pesticides; and
>
> e. properly dispose of excess pesticides so as to create minimal impact on the environment.
>
> "To accomplish these purposes, a routine use inspection should entail two distinct activities as a general matter:
>
> 1. a discussion with the user of the importance of proper pesticide use. Topics which should be covered include the existence and purpose of the FIFRA; the importance of following label directions for use; the need to use pesticides safely and to protect human health and the environment by observing all label precautions during all phases of use (e.g., mixing, application and disposal).
>
> 2. the observation of the actual act of pesticides use (including preparation and disposal, as well as application). To the greatest extent practicable, the inspection should not involve interfering with the user's equipment or performance of his work. To this end, a routine use investigation will not involve sampling a diluted pesticide at the use site.

"The observation and the consequences of the application may be documented by the collection of environmental samples (e.g., soil, foliage, water, and other items carrying pesticide residue), photographs, and records of observation or discussions, including affidavits of persons approached."*

In performing use observations, selected aspects of the pesticide use process can be observed if desired, rather than the entire process itself. That is, the pesticide use process can be subdivided into a number of discrete steps, e.g.:

- Transport of the pesticide to application site;
- Mixing of the pesticide;
- Loading of the pesticide into the application equipment;
- Wearing proper protective clothing;
- Actual pesticide application;
- Disposal or storage of excess pesticides;
- Disposal of empty pesticide containers;
- Adherence with re-entry intervals (if applicable); and
- Adherence with pre-harvest intervals (if applicable).

Therefore, if the inspector were interested in one step of the pesticide use process, he need not observe the entire process.

In order to properly implement this procedure, (e.g., to make it as cost-effective as possible), it would first be necessary to select those pesticide/applicator/use situations (PAU's) and/or those aspects of the pesticide use process that have the greatest potential for health and environmental damages from pesticide misuse. Then it would be necessary to select individual users of each PAU to be subject to use observations. The ranking system of pesticide misuses (i.e., Chapter 3) provides a basis for ranking such PAU's and/or aspects of the pesticide use process. Therefore, the system can be used (and was intended to be used) to provide guidance for selecting PAU's and/or aspects of the pesticide use process to be the focus of routine inspection reports. Individual users can be randomly selected once a set of rules are established (e.g., one rule might be that the same user should not be observed more than once until all users are

*EPA, PTSED, Pesticide Inspection Manual, Section 15, October, 1976, pages 3-4.

observed at least once). In addition, guidance for selecting individual structural pest control operators to be subject to use inspection has been provided by the PTSED and could be utilized as well.*

The use observation technique can also use reports from other PLAINS techniques and from other data sources to select individuals for use observations. That is, these other types of data can serve to guide the allocation of the use observation effort to the observation of high volume users, to the use of pesticides in ecologically sensitive areas (marshlands, tidal areas) to the observation of users who have misused pesticides in the past, etc. In other words, the data on total pesticides, type of crop, etc. will be available to the use observers from other PLAINS techniques and these data can guide the use observer in directing his efforts.

Detection of Misuse and Methods of Data Generation

Through the use observation technique, pesticide misuses (if they occur) would be readily detected since they would be personally observed by the use investigator. Similarly, the data required to measure the extent of pesticide misuse (as described in Exhibit 11) can be readily determined through the use observation technique, if, in fact, a violation of the label requirements is noted during the routine use inspection. In other words, by talking with the pesticide user and by observing the actual act(s) of pesticide use, the pesticide inspector (e.g., EPA Consumer Safety Officer) can determine the date and location of the misuse, the type of misuse that has occurred, the type and amount of pesticide misused, the severity of the damages that resulted or would have resulted (if the inspector curtailed the pesticide use prior to resultant damage), the factors leading to misuse, etc.

It is also possible through the use observation technique to Collect and maintain data which describe the misuse events by a series of dimensions or scales. For example, "severity of damages" could have dimensions of time (hours, years), space (acres), number of organisms, number of animal/human generations, number of species, dollar value of animal, human and/or plant damages, etc. These severity variables could preferably be measured whenever a misuse event is observed in the course of a use observation.

If no misuse is observed during a use observation, it would still be possible to measure the application of the pesticide on the basis of probability or chance of misuse occurring in any one of, say, five, ten or one hundred such applications. Such a measurement could be made by means of a subjective judgment on the part of the observer, based on his subjective impression of the carefulness and expertise of the applicator or applicator team. This judgment could be the best assessment of the chance of a misuse of a certain type and/or severity occurring given the PAU being observed. These assessments can be made for any one or more of the application steps listed above, they would not have to be connected with the applicator's name and, they could he stored in the use observation data file of the PLAINS.

*Enforcement Priorities in Structural Pest Control, Memorandum from Mr. Stanley Legro, Assistant Administrator for Enforcement, to Regional Administrators, January 24, 1977.

Moreover, once the data base of use observations performed by pesticide inspectors is sufficiently large, incidence rates (i.e., frequencies) for particular types of misuse can be developed. If desired these incidence rates can also incorporate the severity of the damages and the cause of the misuse. Thus, a data base of expected misuse would evolve which would both provide input to the development of models of misuse and more effective compliance strategies. It can also aid in the analysis and interpretation of residues and damages data which are obtained independently of observed misuses.*

Data Recording Procedures

Standardized recording procedures would be necessary to document the information obtained during a use observation. Exhibits 13 and 14 illustrate recording forms currently being used by Federal EPA inspectors and State of California inspectors, respectively.** Detailed instructions are provided by the respective agencies for completing these forms so that the information requested on the forms is properly recorded.***

Operational Feasibility and Resource Cost

From an operational feasibility standpoint, it is worthy to note that FIFRA, as amended, does not provide the statutory authority to enter premises to perform use observations unless it is the entry of establishments of persons who offer "for hire" application services of the pesticides which they hold for distribution or sale. Therefore, those establishments subject to this statutory authority (i.e, Section 9(a) of FIFRA, as amended) may only include "the primary place of business of a commercial pesticide applicator, his service vehicle and any other service equipment which he uses to hold the pesticide for distribution or sale."**** Thus, in the absence of a specific grant of statutory authority, use observations require the voluntary consent of anyone other than the people explicitly defined by FIFRA.***** Operationally, use observation as a measurement technique should rely on voluntary cooperation.

A second consideration when performing use observations is the resource costs and manpower requirements. It should be recognized that a full use observation (i.e., observing all aspects of pesticide use) can involve a considerable amount of time as indicated by Exhibit 15. Various state and Federal officials have indicated****** that their enforcement staffs are just not adequate to do routine use inspections because their available time for use enforcement is fully

---

*Further discussion of data analysis appears in the Data Recording, Storage and Analysis Procedures section of this chapter (see page 85).

**Notably excluded from these forms is information concerning why the misuse occurred, i.e, those factors that led to the misuse occurrence.

***Also see the Data Recording, Storage and Analysis Procedures section of this chapter (see page 85).

****EPA, PTSED, Pesticide Inspection Manual, Section 15, October, 1976. p. 1.

*****The same can be said of state pesticide laws and thus state investigators must also operate under these conditions. Se EPA, Office of Pesticide Programs, Operations Division, Digest of State Pesticide Use and Application Laws, June 1976.

******Based on telephone conversations held in September, October, and November, 1976.

Exhibit 13: Use Investigation Report

USE INVESTIGATION REPORT

1. PERSON INTERVIEWED
a. NAME
b. ADDRESS
c. TELEPHONE

2. APPLICATOR
a. NAME
b. ADDRESS
c. TELEPHONE
d. CERTIFICATION NUMBER

3. SITE OF APPLICATION
a. NAME
b. ADDRESS
c. TELEPHONE
d. TYPE OF BUSINESS
e. CROP, AREA OR OBJECT TREATED
f. TARGET PEST
g. DATE AND TIME OF APPLICATION
h. WEATHER AT TIME OF APPLICATION *(Wind, temperature, humidity, rain, etc., list source of information)*

4. PESTICIDE APPLIED
a. BRAND NAME
b. EPA REG. NO.
c. BATCH NO.
d. CLASSIFICATION
e. TYPE OF FORMULATION
☐ DUST ☐ SPRAY ☐ GRANULAR ☐ MIST ☐ FOG ☐ OTHER *(Specify)*:

5. RATE OF APPLICATION
a. METHOD OF APPLICATION
☐ GROUND ☐ AERIAL ☐ OTHER *(Specify)*
b. DILUTION RATE
c. DILUTED MATERIAL APPLIED PER UNIT *(Gallons/Acre)*
d. ACTUAL ACTIVE PER UNIT *(Lbs/Acre)*

6. SAMPLES COLLECTED *(List sample numbers)*
a. FORMULATION
b. DILUTED MATERIAL
c. RESIDUE

7. WERE THE FOLLOWING LABELING INSTRUCTIONS FOLLOWED? ☐ YES ☐ NO *(If "NO", check and explain.)*
☐ TARGET PEST
☐ METHOD OF APPLICATION
☐ DILUTION USED
☐ OTHER:
☐ RATE OF APPLICATION
☐ CROP, AREA OR OBJECT TREATED
☐ CAUTIONARY LABELING
☐ REENTRY INTERVAL
☐ APPLICATOR CERTIFIED
☐ PREHARVEST INTERVAL

8. CONSEQUENCES OF USE *(List any unusual results or adverse effects from treatment)*

9. REMARKS

10. DATE OF INVESTIGATION	11. TIME	12. INVESTIGATOR *(Signature)*	13. TITLE

EPA Form 3540-20 (4-75)

DISTRIBUTION: WHITE - REGION
CANARY - INTERVIEWEE
PINK - HEADQUARTERS
GOLDENROD - INSPECTOR

Source: EPA/PTSED, Pesticide Inspection Manual, Section 15, October 1976, p. 19.

Exhibit 14: Use Observation Data Recording Form

______________ COUNTY
DEPARTMENT OF AGRICULTURE

PEST CONTROL EQUIPMENT, OPERATION AND SAFETY REPORT
511-034 (REV. 8 74)

DATE

TIME ☐ AM ☐ PM

WIND VELOCITY M.P.H.

WIND DIRECTION

☐ PCO ☐ AGRIC JOB ☐ GROUND ☐ SPRAY ☐ FUMIGATION

☐ GROWER ☐ NON-AGRIC JOB ☐ AIR ☐ DUST ☐ OTHER ______

FIRM | PHONE

ADDRESS

EQUIPMENT OPERATOR | EQUIPMENT OR PLANE NO.

REASON FOR INSPECTION

☐ EQUIPMENT INSPECTION ☐ FIELD OPERATION ☐ EMPLOYER HEADQUARTERS ☐ COMPLAINT

☐ REGISTRATION CHECK ☐ WORK SITE ☐ CONTAINER CONTROL ☐ OTHER ______

GROWER | LOCATION

CROP BEING TREATED | ADJACENT CROPS (N) (S) (E) (W)

LOCATION OF ADJACENT ROADS, OCCUPIED BUILDINGS, ETC.

PESTICIDE USED	TOXICITY GROUP *	PESTICIDE USED	TOXICITY GROUP *
1.		3.	
2.		4.	

COMPLIANCE

EXPLAIN NON-COMPLIANCE RESPONCES UNDER REMARKS — *IF ITEM DOES NOT APPLY, WRITE "N.A."

YES	NO		YES	NO	
		1. CURRENT STATE LICENSE			13. COMPLIES WITH LABELING
		2. PROPER COUNTY REGISTRATION			14. MAINTAINING PROPER RECORDS
		3. VALID PESTICIDE PERMITS			15. NOTICE OF INTENTION FILED
		4. EQUIPMENT IN GOOD REPAIR AND SAFE			16. REPORT OF LOSS FILED
		5. NAME AND ADDRESS ON EQUIPMENT			17. EMERGENCY MEDICAL CARE POSTING
		6. EXERCISING REASONABLE PRECAUTIONS			18. MEDICAL SUPERVISION PROVIDED
		7. PERSONS CLEAR OF PROPERTY TREATED			19. EXTRA OUTER CLOTHING AT WORK SITE
		8. SAFETY EQUIPMENT FURNISHED WORN			20. WASHING FACILITIES AT WORK SITE
		9. PESTICIDES AND USED CONTAINERS UNDER SUPERVISION OR IN LOCKED ENCLOSURE			21. CHANGE ROOM OR AREA ADEQUATE
					22. WORKING ALONE OR UNDER SUPERVISION
		10. SUBSTANTIALLY CONFINING MATERIALS TO AREA BEING TREATED			23. 18 YEARS OLD OR OVER (MIX AND LOAD)
					24. EMPLOYEE TRAINING PROVIDED – RECORDS
		11. PROPER CONTAINER RINSING, STORAGE, AND DISPOSAL			25. ADEQUATE LIGHTING AT FILL SITE
					26. RE-ENTRY SAFETY INTERVAL COMPLIANCE
		12. KNOWLEDGE OF SAFETY REQUIREMENTS			27. PROPER POSTING OF TREATED AREA

REMARKS

SIGNATURE OF EQUIPMENT OPERATOR OR PERSON INSPECTED

E-11

ENFORCING OFFICER | NOTICE OF VIOLATION ISSUED ☐ YES # ______ ☐ NO

COPY TO PERSON INSPECTED

Source: California Department of Food and Agriculture.

Exhibit 15: Summary Analysis of Inspection Activities and Man-Hours Spent by Grant Inspectors in California, January through September, 1975

Type of Inspection	San Joaquin County Number of Inspections	San Joaquin County Number of Man-Hours*	San Joaquin County Average Man-Hours/ Inspection	Sutter County Number of Inspections	Sutter County Number of Man-Hours*	Sutter County Average Man-Hours/ Inspection.	Tulare County Number of Inspections	Tulare County Number of Man-Hours*	Tulare County Average Man-Hours/ Inspection
Equipment	25	15	0.60	72	54-½	0.76	75	78	1.04
Application	46	32	0.70	282	197-½	0.70	360	291-½	0.81
Storage/Disposal Container Control	226	116	0.51	22	15-½	0.70	1,627	386	
Mixing & Loading	0	0	0	2	2	1.00	299	223	0.75
Worker Safety	92	52	0.57	109	112	1.03	92	98-½	1.07
Conflict w/Label	5	2	0.40	0	0	0	1	2	2.00
Re-entry Posting	304	97	0.32	2	1	0.50	217	106	0.49
All Inspection Types	-	-	3.10	-	-	4.69	-	-	6.16

*Actual time spent on activity.

Source : State of California, Department of Food and Agriculture, 1975 Pesticide Use Enforcement Grant, Final Report, January, 1976.

spent in investigating pesticide accident reports (which is a required activity). Moreover, some officials were skeptical of the usefulness of use observations, indicating that a pesticide user would not knowingly violate the label if observed by a pesticide inspector. On the other hand, the use observer will get a good picture of label misunderstandings and carelessness.

Nevertheless, use observations have been routinely undertaken in various EPA Federal regions and states.* They do serve a useful purpose in that they can provide much information concerning the details of a pesticide use situation and the practices employed by pesticide users. Moreover, they can serve as a compliance strategy in that they put pesticide users on notice that pesticide enforcement officials are concerned that they use pesticides in a manner that is safe and consistent with the pesticide labeling.**

PESTICIDE USER AUDIT

Detection of Misuse and Methods of Data Generation

The basic approach of the user audit technique for misuse measurement is first to review individual pesticide usage reports and then to question the pesticide user associated with the usage report where there is reason for concern or where there is probable cause to believe that a pesticide may have been misused.

Consequently, data on pesticide usage by individuals must first be obtained. Fortunately, a variety of existing reports can be used as data sources to review pesticide usage, e.g.,

- Pesticide dealer records (required under Section 8 of FIFRA, as amended);
- Restricted use permits issued (some states*** -- e.g., California -- use a permit system to control the use of restricted use pesticides and require a different permit for each restricted material to be used. Documented in the permit is information such as the restricted material in question, site of application, pest to be controlled, number of acres (or other appropriate unit) to be treated, and possible other specific conditions of possession -- see Exhibit 16);
- Pesticide use reports (required in some states***

*In addition, four large scale use observations were performed during the summer of 1976 by the National Enforcement Investigations Center (NEIC) of the EPA. For more information, NEIC or the PTSED/EPA should be contacted.

**Also see Chapter 6, subsection on Institutional/Organizational Considerations.

***See EPA, Office of Pesticide Programs, Operations Division, Digest of State Pesticide Use and Application Laws, June, 1976.

Exhibit 16: State of California Department of Food and Agriculture Restricted Use Form

AGRICULTURAL COMMISSIONER

Address:

Phone:

Permit No. ____________

Seasonal ☐

Single Application ☐

APPLICATION TO POSSESS AND USE RESTRICTED MATERIALS/HERBICIDES

Spray	Dust	Other		Spray	Dust	Other		Spray	Dust	Other		Spray	Dust	Other	
			Aldrin				DDT				MCPA				Systox
			Aluminum Phosphide				Dieldrin				Monitor				Temik
			Arsenic Compounds				Di-Syston				OMPA				Tepp
			Avitrol				EPN				Parathion				Thimet
			Azodrin				Ethion				Paraquat				Thiodan
			Banvel				Endrin				Propanil				Torak
			BHC				Furadan				Phosdrin				Tordon
			Bidrin				Guthion				Phosphamidon				Toxaphene
			Cadmium Compounds				Heptachlor				Sevin				Trithion
			Carbon Bisulfide				Lannate				Silvex				Zinc Phosphide
			Chlordane				Lindane				Starlicide				2, 4-D
			Chloropicrin				Methyl Bromide				Strychnine				2, 4, 5-T
			Compound 1080				Methyl Parathion				Sulfotepp				2, 4-DP
			DDD (TDE)				Mercury Compounds				Supracide				2, 4-DB

EXACT LOCATION OF AREA TO BE TREATED

COUNTY NO.	TOWNSHIP	RANGE	SECTION	BASE AND MERIDIAN

PERMITTEE:	COMMODITY:
MAILING ADDRESS:	PEST (S):
CITY: ZIP:	TOTAL ACRES OR UNITS TO BE TREATED:
PHONE:	METHOD OF APPLICATION: ☐ AIR ☐ GROUND ☐ OTHER
ADEQUATE STORAGE FACILITIES ☐ YES ☐ NO	APPLICATOR:

I understand that this permit is valid for possession and use only when:

(1) Used in accordance with the label.
(2) Conditions of this permit are followed.
(3) Applicable Laws and Regulations are followed.
(4) Pesticide use reports are properly submitted within the time limit prescribed by Regulations.

I further understand that this permit does not relieve me from liability for any damage to persons or property caused by the use of these material(s). Applicant waives any claim of liability or damages against the County Department of Agriculture based on the Issuance of this permit or on any subsequent court order declaring this permit invalid and on any future damages suffered by the applicant by reason of the issuance of this permit or his reliance thereon.

PERSON OR FIRM APPLYING FOR PERMIT	SIGNATURE ▶	TITLE	DATE

PERMIT TO POSSESS AND USE RESTRICTED MATERIALS/HERBICIDES SHOWN IN THE ABOVE APPLICATION

This permit is conditioned upon compliance with all Laws and Regulations governing the possession and use of pesticides and upon compliance with the following conditions:

THIS PERMIT EXPIRES: ____________
UNLESS SOONER REVOKED.

AGRICULTURAL COMMISSIONER

By ____________

Date ____________ Time ____________

Exhibit 16: State of California Department of Food and Agriculture Restricted Use Form (Continued)

GUIDELINES FOR FORMS DESIGN
RESTRICTED MATERIALS/HERBICIDE PERMIT

Sections 2464 and 2552 of the California Administrative Code require that permits to use or possess a restricted material or herbicide be on a form approved by the Director. In the interest of uniformity, the general format outlined should be used. Proposed forms should be submitted to agricultural Chemicals and Feed for review.

The permit form consists of four general parts:

1. List of materials - the list of restricted materials/herbicides may be shortened by eliminating those which are little used in the county. This would increase the area available for optional items felt to be necessary to meet local needs. This area can be used to indicate various formulations of material or special county policy pertaining to certain materials. Materials may be grouped according to handling policy.

2. Information about permittee and application - this part should gather the information necessary to evaluate the application.

3. Liability release statement - it should contain acceptance of responsibility by permittee and a waiver of claim for damages against the Department of Agriculture.

4. Conditions of permit - this area should contain the general conditions that apply to every permit and space for special conditions that may vary with each permit issued.

Optional items may be considered according to local needs:

1. Name of medical facility providing emergency medical care and/or doctor providing medical supervision for persons employed to handle pesticides or work in treated fields.

2. Information relative to notice of intent to apply in counties where notice of intent is used.

3. A map of the area is sometimes useful to determine if susceptible crops are growing nearby or to indicate the presence of schools, recreation areas, homes, etc. If a map is desired, consideration should be given to using a separate form or the back of the permit form. Space for a meaningful map on the form is limited.

4. A provision to indicate renewals of permit.

5. A provisions for permittees to certify to the dealer possession of a valid permit.

6. Other items desired and felt to be necessary on a local basis.

Exhibit 16: State of California Department of Food and Agriculture Restricted Use Form (Continued]

GUIDELINES FOR FORMS DESIGN
RESTRICTED MATERIALS/HERBICIDE PERMIT

Sections 2364 and 2552 of the California Administrative Code require that permits to use or possess a restricted material or herbicide be on a form approved by the Director. In the interest of uniformity, the general format outlined should be used. Proposed forms should be submitted to agricultural Chemicals and Feed for review.

The permit form consists of four general parts:

1. List of materials - the list of restricted materials/herbicides may be shortened by eliminating those which are little used in the county. This would increase the area available for optional items felt to be necessary to meet local needs. This area can be used to indicate various formulations of material or special county policy pertaining to certain materials. Materials may be grouped according to handling policy.

2. Information about permittee and application - this part should gather the information necessary to evaluate the application.

3. Liability release statement - it should contain acceptance of responsibility by permittee and a waiver of claim for damages against the Department of Agriculture.

4. Conditions of permit - this area should contain the general conditions that apply to every permit and space for special conditions that may vary with each permit issued.

Optional items may be considered according to local needs:

1. Name of medical facility providing emergency medical care and/or doctor providing medical supervision for persons employed to handle pesticides or work in treated fields.

2. Information relative to notice of intent to apply in counties where notice of intent is used.

3. A map of the area is sometimes useful to determine if susceptible crops are growing nearby or to indicate the presence of schools, recreation areas, homes, etc. If a map is desired, consideration should be given to using a separate form or the back of the permit form. Space for a meaningful map on the form is limited.

4. A provision to indicate renewals of permit.

5. A provisions for permittees to certify to the dealer possession of a valid permit.

6. Other items desired and felt to be necessary on a local basis.

Exhibit 17: State of California Department of Food and Agriculture - Pesticide Use Report Form

READ THE LABELS PROTECT THE ENVIRONMENT

DISPOSE OF USED PESTICIDE CONTAINERS AND SURPLUS PESTICIDES SAFELY.

STATE OF CALIFORNIA DEPARTMENT OF FOOD AND AGRICULTURE – PESTICIDE USE REPORT

OPERATOR NAME & ADDRESS 310849

County No. 1	Section 2	Township N S 3	Range E W 4	Base & Meridian S M H 5	Date(s) Applied 6	Commodity Treated 7

16

Method of Application Ground ____ Air ____ Other 8	Total Acreage or Units Treated 9	Volume Per Acre 10	Supplier 11

CUSTOMER 17

LOCATION 18

ADDRESS 19

12 Name of Product Applied	13 California Registration Number	14 Rate per Acre	15 Pest(s) Treated
			A
A			B
			A
B			B
			A
C			B
			A
D			B
			A
E 310849			B

APPLICATOR & NO. 20			PERMIT NO. 21	
TEMP. L H 22	Posted yes ____ no ____ date	WIND N W E S 23	MPH L H 24	TIME AM 12 9 3 6 PM 12 9 3 6 25

RATE OF CHARGE	TOTAL CHARGE $

ORDERED BY ____

511-025 REV. 10-70 (REV. 12-72) TO AGRICULTURAL COMMISSIONER*

*Copies of this report form **go** to the State and the applicator.

by those who apply pesticides “for hire” and by those who apply restricted use materials under permit -- see Exhibit 17); and

- Agricultural pest control advisor records (required by some states* by those who supply recommendations to growers of agricultural crops or commodities -- see Exhibit 18).

Detection of Misuse--

Based upon the information obtained in the use report, the detection of certain kinds of label violations may be possible. That is, if the usage report contains detailed information such as that required in Exhibit 17, indications for many types of misuse could be suggested _if_ this information were compared to the pesticide's labeling requirements and/or the restricted material permit issued in order to use the particular pesticide (e.g., Exhibit 16). For example, if the restricted material permit indicated a certain amount of a given pesticide to be applied to a given size area and the usage report was not consistent with these requirements, then some sort of misuse probably occurred, e.g., improper application site or improper dosage rate (unless the usage report was improperly completed). However, for the most part, review of these reports would _not_ provide a basis for adequately assessing the extent of misuse (i.e., type of misuse, factors leading to the misuse, severity of the misuse incident, etc.) associated with the usage report. Therefore, _questioning_ the pesticide user associated with these reports would be necessary,.

In addition, certain reports, once reviewed, may be of interest _regardless_ of whether they raise particular questions of possible misuse. For instance, if a highly toxic pesticide was or is to be used, or if an unusually large quantity of a pesticide was used or bought, of if the pesticide was applied or is to be applied in the vicinity of schools, dwellings, hospitals, recreational areas, food handling establishments, susceptible crops, etc. or, if the applicator has violated the law on previous occasions, questioning the pesticide user may be desirable to check on the usage of the pesticide.

Assessing the Extent of Misuse--

Questioning the pesticide user in order to assess the extent of misuse as outlined in Exhibit 11, can take on one of several forms. For example, an inspector can simply make arrangements to talk with the pesticide user and then ask him penetrating questions about the pesticide usage report. Included could be questions on one or more of the following topics:

- Amount of the pesticide purchased;

- Proper credentials (i.e., certification and/or licensing);

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*See EPA, Office of Pesticide Programs, Operations Division, _Digest of State Pesticide Use and Application Laws_, June, 1976.

Exhibit 18: State of California Department of Food and Agriculture - Pest Control Recommendation Form

510-092 (Est.-7-72)

PEST CONTROL RECOMMENDATION

To	Address	
Location of Property to be Treated	Commodity	Acres or Units

Pest (s)

MATERIAL	RATE PER ACRE	DILUTION RATE	VOLUME PER ACRE

Special Remarks (conditions, precautions, re-entry, etc.)

Adviser's Employer

Adviser's Signature	Date

- Evidence of the pest problem;
- Location of pesticide use;
- Mixing and loading practices;
- Calibration of application equipment;
- Application method(s) and total amount used;
- Protective clothing worn;
- Disposal and storage practices for empty containers and unused pesticides;
- Re-entry intervals and posting of field (if applicable);
- Pre-harvest intervals (if applicable); and
- Other safety precautions followed.

A series of subjective judgments or estimates could be made on the basis of the answers to these questions, and these estimates could be coded by PAU as part of the audit data file on expected frequency of misuse.

An alternate form for eliciting this kind of information from the pesticide user could involve the use observation technique and could occur *either* prior to any application activity (e.g., as a result of reviewing restricted material permits, dealer records, or advisor recommendations) *or* subsequent to some initial application activity (e.g., a use observation performed as a result of reviewing a pesticide use report filed by the applicator). However, a necessary factor for using this approach is to know *when* the user in question will be applying the pesticide. For example, in California, users of restricted use materials can be subject to pesticide user surveillance and moreover, the County Commissioner can require that a "notice of intent" be submitted to his office prior to the use of a restricted material to allow for his inspection of the application.*

Consequently, in those situations where the time of application cannot be determined, the alternate approach of questioning the user about the usage report *after* it is received will provide a valid alternative to use observation.

Operational Feasibility

As indicated above, the availability of individual pesticide usage reports will be a critical factor in determining the feasibility of this approach since

California State Plan for Certification of Applicators (Draft) July 2, 1976, pp. 5-8.

these are the key data sources for obtaining information on pesticide usage. A review of the Digest of State Pesticide Use and Application Laws* indicates that of 78 laws analyzed (some states have more than one use and application law), 48.7 percent require restricted use permits, 30.8 percent require purchase permits, 29.5 percent require written recommendations from advisors, 34.6 percent require accident reporting and 92.3 percent require that copies of records be furnished to the appropriate state regulatory body if requested. Consequently, it is possible that only one-third to one-half of the states could effectively implement pesticide user audits given the reporting requirements of the state use and application laws.

This approach will also be dependent upon the financial resources available for such a monitoring effort. Consequently, to maximize this effort, priority should be given first to reviewing those user reports involving PAU's indicated by the ranking procedure as having potentially severe human health or environmental impacts if pesticide misuse should occur.

Concluding Remarks

In sum, through the two step audit procedure of first-reviewing individual usage reports, and second-questioning those users whose reports raise some concerns or discrepencies, label violations can be detected, and more importantly, the type of misuse, the severity of damages, the factors leading to the misuse, and the frequency of the occurrence can be assessed and systematically catalogued for analysis.

Depending upon the available data sources and financial resources allocated to reviewing usage reports and performing follow-up questioning, the level of misuse detection could range from uncovering only the gross types of misuse (e.g., improper certification, improper application site, or improper storage practices) to uncovering the more subtle forms of misuse (e.g., improper target pest or improper dosage rate if too low).

In addition, through pesticide user audits, spinoff effects vis-a-vis achieving compliance with pesticide labeling requirements may result, as users hear of others in their same profession who were subject to a pesticide user audit.**

MONITORING REPORTS OF HEALTH AND ENVIRONMENTAL DAMAGE

Introduction and Approach

Monitoring pesticide damage reports and episodes is a well established process within Federal and state environmental agencies. For example, various networkds are presently in place for receiving and monitoring reports of pesticide related health or environmental damages (e.g., the Pesticide Episode Reporting System (PERS) maintained by the Pesticide Episode Response Branch/Opera-

*EPA, Office of Pesticide Programs, Operations Division, op. cit.

**Also see Chapter 6, subsection on Institutional/Organizational Considerations.

tions Division/OPP/EPA, the nationwide force of Consumer Safety Officers maintained by the PTSED/EPA, etc.). These networks provide a basis for the development of a system for monitoring health and environmental damage reports. Such a system must operate in two modes:

- Detect potential cases of misuse by monitoring data collected through existing damages reporting systems; and

- When a misuse is detected by special damages monitoring techniques, ensure that data are fed into one or more existing systems (e.g., PERS, Poison Control Centers).

These "modes" imply that any misuse detected via resultant damages will be compiled by one or more systems, and any misuse entered into one or more of these systems will be labeled as a misuse report. The "set" of all misuses will be completely contained in the set of data within the presently established damages reporting systems.

Thus, the approach suitable for the damages monitoring component of the overall PLAINS is to make maximum use of existing damages reporting systems. It is possible that some misues will consist of a label violation without a resulting "damage" (in the sense of the damages typically compiled into the existing damages monitoring systems). Consequently, the damages monitoring technique need only apply to misues where damages actually occur. Other techniques (e.g., use observation, pesticide user audit) will detect and measure "non-damage" violations.

Detection of Misuse and Methods of Data Generation

Detection of Misuse by Analysis of Data in Existing Damages Reporting Systems--

The damages monitoring technique, in order to operate successfully, will require a sampling (i.e., monitoring) of reports from existing damages reporting systems, e.g.,

- The Pesticide Episode Reporting System (PERS) data resulting from telephone calls to EPA, EPA investigation of reported episodes or episodes heard about through the other reporting systems below* (see Exhibit 19 for the PERF form utilized in the PERS);

*Reports generated by the other systems may be included in the PERS if a PERF form is sent in to EPA by the system.

Exhibit 19: Pesticide Episode Report Form (PERF)

PESTICIDE EPISODE REPORT FORM
(PERF)

Form Approved
OMB No. 158-R0008

Year 19____ (1-2) Region____ (3) File No. ____________ (4–8)

Type of Action
9,1 ☐ Delete
2 ☐ New
3 ☐ Correct
10 ☐1

FIPS Location Code /__/__/__/__/__/__/__/__/__/ (11–19)
state city county

Reporting Agency /__/__/__/__/ (20–23)

Processed By ________ ________ Date__/__/__

Attachments ☐ Yes ☐ No

INSTRUCTIONS FOR COMPLETING THIS FORM

Carefully read these instructions before you begin filling out the form below.

A. Shaded areas are to be completed by the EPA Regional Office.

B. Carefully review the instructions included in each section before answering. Each question can have only ONE answer or box checked unless otherwise indicated.

C. Print all required information.

D. If you check "OTHER" be certain to print explanation in the space provided.

E. Space is provided on the back page of this form for remarks.

F. If attachments are included, staple them securely inside the form before folding.

G. When form is completed, fold and mail.

Thank you for your cooperation.

I. GENERAL EPISODE INFORMATION

Please check the ONE most appropriate response unless otherwise indicated. Print all written information on the lines provided.

1. This report form prepared by:

____
Name
____
Telephone number
____
Agency/affiliation

2. Initial source of information ________________________

____

3. Date report prepared ____/____/____
Month (24-25) Day (26-27) Year (28-29)

Example: May 29, 1974, write 05/29/74

4. Date of episode ____/____/____
Month (30-31) Day (32-33) Year (34-35)

5. Location of episode

City________________________ (36–49)

County________________________ (50–63)

State Abbreviation ____________

6. Has the pesticide(s) associated with this episode been established as the causative agent(s) which resulted in death, illness, plant damage, etc.?

64,1 ☐ Yes
2 ☐ Probable
3 ☐ Undetermined

7. Was transportation of pesticide involved?

65,1 ☐ Yes
2 ☐ No

8. Was a fire, flood, hurricane or other disaster involved in this episode?

66,1 ☐ Yes
2 ☐ No

9. Was this episode:

67,1 ☐ In or around the home area
2 ☐ Agriculture related
3 ☐ Industrial
4 ☐ Other, specify________________

10. Did this episode involve the disposal of:

68,1 ☐ Pesticide
2 ☐ Container
3 ☐ Plant Material
4 ☐ Animal
5 ☐ Other, specify________________
6 ☐ Disposal NOT involved

11. Did this episode result in contamination of:
(Check ALL that apply)

69,1 ☐ Water
70,1 ☐ Food
71,1 ☐ Vehicle
72,1 ☐ Building
73,1 ☐ Other, specify________________
74,1 ☐ No contamination

12. Is follow-up of this episode planned?

75,1 ☐ Yes, By________________
2 ☐ No
3 ☐ Already completed

EPA Form 8550-4 (Rev. 7-74) PREVIOUS EDITIONS ARE OBSOLETE

Sequence /2/ / / / (10, 11 12)   Type Pesticide Code / / / / (13, 15)

II. PESTICIDE INFORMATION

Please complete this section by printing written information on the lines provided. Where a box is provided, check the ONE most appropriate response. Complete a separate PESTICIDE INFORMATION section for each additional PESTICIDE PRODUCT (NOT active ingredient) involved in this episode.

1. **Number of PESTICIDE PRODUCTS (NOT active ingredients) involved in this episode:** ______ (16-17)

2. **LABEL INFORMATION:**

   Copy the following information from the product label if available. If Product Name, Part A, is not known, PRINT "UNKNOWN". Partial or trade names are acceptable if the full product name is not known.

   A. **Product Name** ______________________ (18 – 59)

   B. **Does label bear the EPA Registration Number?**

   60, 1 ☐ Yes
   2 ☐ No
   3 ☐ Unknown

   C. **EPA Registration Number** / / / / / / - / / / / / / - / / / / / / (61, 65 66, 70 71, 75)

3. **What is the type of pesticide?**

   76, 1 ☐ Insecticide
   2 ☐ Herbicide
   3 ☐ Fungicide
   4 ☐ Rodenticide
   5 ☐ Disinfectant
   6 ☐ Combination and/or other, specify______________
   7 ☐ Unknown

4. **Is this pesticide registered for:**

   77, 1 ☐ Restricted use
   2 ☐ General use
   3 ☐ Unknown

5. **Was the applicator certified at the time of the episode?**

   78, 1 ☐ Yes
   2 ☐ No
   3 ☐ Unknown
   4 ☐ No applicator (Spillage, fires, etc.)

6. **What was the method of application?**

   79, 1 ☐ Aerial
   2 ☐ Ground
   3. ☐ Hand
   4 ☐ Other, specify______________
   5 ☐ Unknown
   6. ☐ No application

7. **What is the formulation of the pesticide?**

   80, 1 ☐ Bait
   2 ☐ Dust
   3 ☐ Granular
   4 ☐ Wettable powder
   5 ☐ Solution
   6 ☐ Emulsifiable concentrate
   7 ☐ Pressurized product
   8 ☐ Other, specify______________
   9 · ☐ Unknown

8. **Enter the ESTABLISHMENT NUMBER in the blocks provided. If unknown, leave blank.**

   /3/ / / / (10, 11-12)   / / / / / / - / / / - / / / (13, 17, 18-19, 20-21)

9. **List the names of the ACTIVE INGREDIENTS. If more than four (4), check here ☐ and list additional ingredients in "REMARKS", Page 4.**

   Seq. /4/ / / / (10, 11-12)

	Sub Seq.	AI Code	CC Code
1.______	13-14	15 – 20	21-22
2.______	23-24	25 – 30	31-32
3.______	33-34	35 – 40	41-42
4.______	43-44	45 – 50	51-52

III. HUMAN INFORMATION

If HUMANS WERE NOT INVOLVED in this episode, skip to Section IV, ANIMAL INFORMATION. Answer questions 1 and 2 by selecting the ONE most appropriate response and checking the box provided. Answer questions 3 and 4 only if the episode was job-related.

1. **Were any of the affected humans suicide or homicide attempts?**

   10 [5] 11, 1 ☐ Yes 2 ☐ No 3 ☐ Undetermined

2. **What was the PRIMARY route of exposure?**

   12,1 ☐ Oral
   2 ☐ Dermal
   3 ☐ Inhalation
   4 ☐ Combination
   5 ☐ Unknown

3. **If the episode was job-related, check the response that most closely describes the occupation of the affected human(s).**

   13-14, 01 ☐ Pesticide formulator
   02 ☐ Formulating plant worker
   03 ☐ Mixer, loader, swamper
   04 ☐ Pest control operator
   05 ☐ Fumigator
   06 ☐ Aerial applicator
   07 ☐ Spray rig operator
   08 ☐ Farmer or rancher (supervisory)
   09 ☐ Harvester or picker
   10 ☐ Other agricultural worker
   11 ☐ Ranch worker (livestock)
   12 ☐ Other, specify______________
   13 ☐ Unknown

4. **If the episode was job-related, was re-entry a factor?**

   15, 1 ☐ Yes 2 ☐ No 3 ☐ Unknown

5. **HUMAN INVOLVEMENT:** *COMPLETE A ROW for each age group(s) involved by entering the number of humans in the appropriate columns. Example: A three (3) year old child was hospitalized and later died as a result of accidental pesticide poisoning. Two older children, ages seven (7) and nine (9) were hospitalized as a result of the incident.*

	HUMAN INVOLVEMENT TABLE						
		Column 1	Column 2		Column 3	Column 4	Column 5
	Age Group	Number Affected	Number of Fatalities: Accidental/ Undetermined	Number of Fatalities: Suicidal/ Homicidal	Number Hospitalized	Number Receiving Medical Treatment But Not Hospitalized	Number Not Treated
	(Example) Less than 5 years	1	1		1		
	(Example) 5 – 16 years	2			2		
16,1 ☐	Less than 5 years						
2 ☐	5 – 16 years						
3 ☐	17 – 65 years						
4 ☐	Over 65 years						
5 ☐	Unknown						
		17-19	20-22	23-25	26-28	29-31	32-34

IV. ANIMAL INFORMATION

IF ANIMALS WERE NOT INVOLVED in this episode, skip to SECTION V, PLANT INFORMATION. COMPLETE ONLY ONE ROW for EACH BREED/SPECIES involved in this episode. Enter the ANIMAL NAME in Column 1 and the ANIMAL TYPE in Column 2. Columns 3, 4, and 5 should be completed if known. If more than five (5) breed/species are involved in this episode, please complete a separate ANIMAL INFORMATION section. Example: Twenty (20) cattle were affected in one episode. Four (4) were known to be Angus and the others were dairy cattle. One (1) dairy cow died; route of exposure was dermal.

	ANIMAL INVOLVEMENT TABLE					
	Column 1	Column 2	Column 3	Column 4	Column 5	
	Name of Breed/Species	Type of Animal 1. Livestock 2. Poultry 3. Wildlife 4. Birds 5. Fish 6. Pets 7. Bee Colonies	Total Number Affected	Total Number Dead	Exposure Route 1 Oral 2 Dermal 3 Inhalation 4 Combination 5 Unknown	Breed/Species Code
	(Example) Angus	Livestock	4		Dermal	
	(Example) Dairy Cattle	Livestock	16	1	Dermal	
						/ / / / / / / /
						/ / / / / / / /
						/ / / / / / / /
						/ / / / / / / /
						/ / / / / / / /
10/6/	11-35	36	37-43	44-50	51	52 58

V. PLANT INFORMATION

IF PLANTS WERE NOT INVOLVED in this episode, proceed to remarks section. COMPLETE ONLY ONE ROW for EACH SPECIES/VARIETY involved in this episode. Enter the PLANT NAME in Column 1 and the PLANT TYPE in Column 2. Columns 3 and 4 should be completed if known. If additional descriptive information is available, use Column 5. If more than five (5) species/varieties are involved in this episode, please complete a separate PLANT INFORMATION section. Example: Thirty-eight (38) Big Boy tomato plants in a home garden and twenty (20) rows of pole beans raised commercially were damaged by pesticide drift. The rows of pole beans were sixty (60) feet long.

	PLANT INVOLVEMENT TABLE					
	Column 1	Column 2	Column 3	Column 4	Column 5	
	Name of Species/Variety	Type of Plant Life 1. Crops 2. Forests 3. Orchards 4. Home Garden 5. Forage 6. Ornamentals 7. Pasture & Range	Number of Acres Affected If Known	Number of Plants Affected If Known	Description Of Affected Area	Species/Variety Code
	(Example) Big Boy Tomato	Home Garden		38		
	(Example) Pole Beans	Crop			20 rows 60 ft. long	
						/ / / / / / / /
						/ / / / / / / /
						/ / / / / / / /
						/ / / / / / / /
						/ / / / / / / /
10/7/	11-30	31	32-38	39-45	46-70	71 77

Thank you for your cooperation.

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- Reports of citizen and trade complaints (the Federal EPA and many states* require a misuse investigation** if such a report is received -- some states require the the report be received in writing);

- Poison Control Center reports of pesticide treated episodes (including reports from hospitals not designated as Poison Control Centers);***

- News media -- television, radio, newspaper -- reports of pesticide related accidents;***

- Physician reports of pesticide treated episodes (some states* require physicians to report cases of pesticide poisoning);***

- Pest control operator reports of pesticide episodes [many states* require that pest control operators who apply pesticide "for hire" report pesticide episodes to a designated state authority);***

- Veterinarian reports (for effects to animals);*** and

- Reports filed with other cooperating agencies (e.g., USDA, FDA, Department of Interior/Fish and Wildlife Service, State and local agencies with similar responsibilities, state and local law enforcement agencies - police departments, etc.).***

There will be several criteria which, when applied to these data, will suggest the possibility of a misuse event, but will not alone be conclusive evidence of misuse. These criteria will include:

- Damages from a specific pesticide in a county or crop region where crops for which that pesticide are registered are not typically grown;

- Other inappropriate or unexpected damages to soil or water, for example, industrial pesticide residues in a rural area;

- Any severe damages event involving fish or wildlife;

- A large pesticide concentration as a mass in a stream or estuary, causing discoloration and odor; and

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*See EPA, Office of Pesticide Programs, Operations Division, op. cit.

**The Federal EPA uses the Use Investigation Report form (Exhibit 13) when investigating alleged misuses; PERF forms may also be completed.

***These reports can generate a federal EPA and/or state misuse investigation as well.

- Any human health episode involving neurologic disturbances of possible toxic etiology.

The detailed development and implementation of this measurement technique will provide more detailed criteria. These criteria will act as "triggers" for more detailed analysis. It is important to keep in mind, however, that any disruption of existing damages reporting systems should be avoided unless legal basis for a follow-up is clearly evident.

In other words, the functioning of existing damages reporting systems (e.g., PERS) depends on voluntary cooperation from many Federal, state and local officials and <u>private</u> citizens. The reporting function could be reduced in its efficiency if it became a large scale stimulus for misuse investigations of applicators and other pesticide uers. People who detect soil or stream damages, improperly discarded containers, or ailing livestock might become more reluctant to report to the PERS, for example, if these people suspected an investigation of their sales or use records would result.

Therefore, the detection of misuse using the existing systems will rely heavily on:

- Detection of <u>anomalies</u> which reveal a high probability of misuse, such as the detection of damages to a crop by a pesticide unregistered for that crop; and

- Detection of <u>improbable</u> illnesses or vegetation damages by using sophisticated statistical techniques and criteria, such as distribution comparisons, maximum likelihood indicators and ecologic models.

In other words, the monitoring (i.e., sampling and analysis) of material in existing damages reporting systems should be organized to progress through a series of "remote", statistical tests, before, and preferably in place of, triggering a field investigation, e.g., user audit or use observation or misuse investigation (unless legally required).

The objective of analyzing data from these damages reporting systems would <u>not</u> be the attainment of conclusive <u>proof</u> that a misuse event has occurred. Once again, it should be noted that the technique for monitoring reported damages due to misuse are intended to provide a basis for <u>resource allocations and compliance strategies, not for legal action</u>. Therefore, the results of the monitoring systems analysis and testing should be a set of categorized <u>indications</u> or probable misuse.

Over a period of time, for example, a month, these indications could be tabulated and reported, e.g.,

- Number of 95 percent probable misuse indications = x

- Number of 75 percent probable misuse indications = y

- Number of 50 percent probable misuse indications = z

Research should provide a measure of the error in each "indications" value, and eventually these values can be specified for types of misuse and geographic regions.

Detection of Misuse by Special Damages Monitoring Systems--

The health and environmental damages monitoring technique will require some special field and local level monitoring, as well as monitoring the existing damages reporting systems described above, in order to detect misuse. This special monitoring will be necessary in order to provide the important "missing link" between damages monitoring data and the underlying mechanisms of misuse. Thus, even though sampling and analyzing the damages reporting systems data, as described above, will provide detections of the probable occurrence of misuse, certain types of additional monitoring will improve the probability of detecting misuse and will provide additional input for interpreting the data from existing damages reporting systems.

Once again, these special damages monitoring systems will not be intended to obtain proof of misuse, but will produce judgments of the probability that misuse has occurred. In addition, these special monitoring reports will include judgments of the type of misuse and factors leading to misuse, and will therefore be comparable with actual use observations and possibly with user audits. The judgments of how and why the misuse occurred can be ascertained by study of the actual site and user. However, this should be done only on a very small scale because of the need for keeping special monitoring costs low and, the previously mentioned danger of discouraging voluntary cooperation in existing damages reporting systems.

The special monitoring effort will require careful attention to potential violations of confidentiality and privacy, particularly in the case of hospital and physician records. The special monitoring personnel must be trained to visit local level agencies, institutions, and other potential sources, and to work out a procedure for obtaining the best possible survey of possible misuse events with a minimum of access to actual case records and agency files. In other words, the special monitoring will include making judgmental assessments using interviews and questionnaire forms.

One potential scenario for the special monitoring program would base the effort on one or two personnel for each Federal EPA region. These pesticide misuse damage monitors would make surveys of a sample from a complete listing of physicians, clinics, hospitals, foresters, game wardens, and anyone else who might recall or have records of specific pesticide episode or damages. A reasonable sample would involve a visit to a small percent of these sources each year, with possible telephone contacts on a different, more frequent schedule.

Under this scenario, the monitor would schedule an interview in which he would review the status of pesticide damages in the respondent's region over the past year. Then the monitor would use open-ended questions to ascertain possible misuse occurrences known by the respondent. Once a case of interest was identified, the monitor could use a questionnaire or check-off list to obtain estimates of the data, including the type of misuse and the factors leading to the misuse.

The respondent could refer freely to his files while discussing cases. If, in the judgment of both the monitor and the respondent, no violation of privacy or confidentiality would occur, then the monitor could refer directly to case records. In hospitals or clinics, the monitor would probably have to develop an annual sampling scheme in cooperation with officials, but any cases which came to light of possible misuse would be reviewed.

Assessing the Extent of Misuse--

As indicated above, the damages monitoring technique will obtain data not only from sampling data from existing damages reporting systems, but also from the special damages monitoring program. The data requirements previously shown in Exhibit 11 are illustrative of what the monitoring personnel will have to look for in the existing damages reporting systems reports and during the special damages monitoring system effort.

The data generated by the judgments of the existing damages reporting systems analysis and special monitoring personnel could be in the form of probabilities of misuse. In addition, it would be possible to make guesses about the type of misuse and the factors leading to the misuse. These probability estimates can be averaged for each case assessed, and an indication of misuse can be the result. The indication can be a value which reflects the probable occurrence of a misuse, and its type and underlying factors.

However, the type of data that can only be obtained by the special damages monitoring system would include the actual process or mechanism by which the damages victims (people, wildlife, etc.) were exposed to the pesticides. This process or mechanism would include the details of the intended application, storage and disposal. and the role of the people exposed. In addition, the relative positions of people, animals, and vegetation from the application site would be found. Admittedly, the health and wildlife personnel might not normally be aware of these details, but in small rural communities there is a reasonable chance that they are familiar with the case from one or more sources.

Nevertheless, if the report of damages available in an existing damages reporting system is highly detailed,* then the damages monitoring technique can provide details gleaned from these reports, regarding the extent of misuse, such as the number of pounds of pesticides dispersed, the number of people affected and the severity of the damages. These data can provide a profile of incidents (episodes) which are judged as possibly arising from misuse. The factors leading to the misuse would still be the most difficult type of information to obtain from the existing damages reporting systems analysis.

The frequency of misuse over time is one additional measure of the extent of misuse which will be obtained from the damages monitoring technique described

*This would be true, for example, if the monitoring system report generated further data gathering activities, e.g., a misuse investigation.

above. Within time periods of one month or longer, the monitoring of reports of damages can provide a frequency measure of misuse indications as noted above. Again, each of these frequency counts could have a probability factor (95 percent, 75 percent, 50 percent) attached and if possible, an estimate of error or "confidence".

Operational Feasibility

The operational feasibility must be assessed on the following criteria:

- Data base and collection efficiency of existing damages reporting systems;
- Potential for overlap, and double counting of cases;
- Feasibility of reliable judgments of probability of misuse; and
- Feasibility of obtaining a manageable and interpretable set of output data.

All of these criteria must be assessed carefully on the basis of a trial implementation of the damages monitoring technique. But at present, the problems involved are well-known and have been overcome in other programs.

Resource Cost

The damages monitoring technique will require manpower for both monitoring reports from existing damages reporting systems as well to perform the special damages monitoring function.

Monitoring reports from existing reporting systems is, to a large extent, currently being done by regional and headquarters EPA personnel and it is expected that little additional manpower (from a Federal EPA standpoint) would be required to fully implement this aspect of the damages monitoring technique.

The program for the special damages system, however, would require additional manpower. The program should be based at the EPA regional level with some coordination and report writing effort at the national level. If an average of 300 counties per region is assumed (there are approximately 3,000 counties in the United States), then the special damages monitoring system could be structured around a one year cycle. For example, each county in a given region could be visited once a year by one person, thus requiring less than 1.5 man-years (one man-year = 200 days; 1.5 man-years = 300 days, or one day per county per region). If two (2) man-years were budgeted in each EPA region, then a little over one-half a man-year would be available in each region for data analysis and reporting. Other costs (e.g., travel) would also have to be taken into account prior to implementation.

PESTICIDE RESIDUE MONITORING

Introduction and Rationale

The misuse measurement techniques described above (use observations, user audit, and damages monitoring) all have a greater or lesser degree of direct contact with the use or application context. The fourth technique, residue monitoring, is most remote. It should be used however, because of its low cost.* Even if a supplementary effort (such as the special damages monitoring effort proposed for the damages monitoring technique) is required, the residue monitoring technique may well evolve into a highly efficient system for detecting and measuring the extent of misuse.

The rationale for a residue monitoring technique derives from the basic existing condition that residue monitoring data are already compiled by networks within EPA, USDA, FDA and the Department of the Interior, e.g.:

- APHIS and FDA residue data inspection reports for agricultural crops and commodities;
- APHIS/Meat and Poultry Inspection residue inspection reports for meat and poultry products;
- Department of Interior/Bureau of Sport Fisheries and Wildlife residue inspection reports for wildlife;
- USGS and EPA inspection reports on water samples;
- EPA sponsored inspection reports for soils (including soils in urban areas); and
- EPA sponsored studies on pesticide residue in humans (blood tests to determine cholinesterase levels, etc.).

Given these data bases, the residue monitoring technique for detecting misuse need only devise the correct data screening and testing procedures to provide at least an indication that a misuse may have occurred.

Detection of Misuse

Some types of residues will lead to an obvious conclusion that some misuse has occurred, especially if the residues of pesticides on foods are screened. For example, if a residue of DDT is found on a crop grown in the U.S., and the use does not associate with a special use permit, then the almost unavoidable conclusions is that some use of an unregistered pesticide has occurred.

---

*By this, it is meant that the cost of using the residue data collected by the various agencies will be relatively low compared to other monitoring techniques. This should not be confused with the cost of obtaining the data, which is undoubtedly quite high, but which would be done regardless of how useful it would be for misuse detection, since other laws and regulations require the collection of residue data.

Residue levels in the environment are less conclusive indicators of misuse, but a probability of a misuse could be assigned to the appearance of a relatively sudden rise in concentrations in soil, groundwater, fish or birds.

These probability assignments would be similar to the system for detecting misuses from existing damage reports described above. The important feature of the residue monitoring technique will be the use of sensitive statistical tests to detect small, but unlikely changes in food and environmental residues which cannot be attributed to emergency treating for unusually heavy pest infestations or to shifts in ecologic processes, such as the sudden intrusion of a pesticide into a groundwater layer, or a decrease in stream flow rates causing a pesticide build up in a lake or pond.

Measuring Extent of Misuse

The frequency of misuse over time will be one easily determined measure of the extent of misuse. That is, this frequency measure will derive from the occurrences of the statistical anomalies described in the subsection above, which are used to assess a probability that misuse has occurred. These probable occurrences, especially those assigned to the 95 percent category, could be tabulated to obtain a frequency measure per month or per year. In addition, the severity of the misuse, if indeed the resultant damage was caused by a misuse, would be readily known by monitoring the residue data.

More development of the residue monitoring technique will be needed to ascertain whether there are adequate data on variables such as location of residues, time period covered, and specific pesticide source. These variables will be needed to determine whether a change in residues indicates a probable misuse such as improper dose. The land use in the area where the residues were detected, as measured by acres for each crop and acres for various types of industry, nurseries, and waste dumps, will be useful in assessing probability of misuse, although compiling such data may require special effort within the residue monitoring network.

Consequently, the more difficult measures of the extent of misuse (e.g., the type of misuse and factors leading to misuse) may be available only on chance occasions from the residue monitoring technique. Even though a rise in residues may be assigned a "high probability of misuse" rating, the question will remain as to whether the misuse was improper dose, improper time interval, improper site, spray drift, improper disposal, etc. Similarly, the motives and associated behavior of the misuse will be hard to assess from residue monitoring, unless other data in addition to residues is used. For example, a large proportion of the variance in pesticide use could probably be explained by a model such as:

$$A = aC + bP + cF$$

A = quantity of pesticide used
C = price of crop
P = price of pesticide
F = level of pest infestation

where the level of infestation could well be the least significant explanatory variable. If such a model were available for use with residue monitoring, it would point out occurrences of low infestation and pesticide applications made on the basis of wishful thinking.

Therefore, to fully assess the extent of misuse, additional follow-up of suspect residue reports may be necessary. These follow-ups could be accomplished through a special damages monitoring effort, through use observations, and/or through user audits (either face to face or telephone) with selected pesticide users concerning their pesticide use practices.

Feasibility

The feasibility of using residue monitoring to measure misuse should be good, since most residue monitoring data bases are at least partly automated. The residue measurements would combine with land use and economic data (and possibly demographic data, such as education, and occupation) to give a complete picture of the nature of the possible misuse. The feasibility of making such combinations is problematic without further pilot investigation.

Resource Cost

The cost of screening and testing residue data would be primarily in the use of automated data equipment, and in the staff of statistical and biochemical personnel. It is estimated that a pilot operation could be started with two such scientists, and eventually, after implementation, the entire program could be run (national level) by a staff of about the same size. The staff of two scientists would be supported by technical and clerical personnel during some periods of the program. But for many analyses, the two scientists would, hopefully, be an adequate number to manage the automated data and to design and perform tests.

DATA RECORDING, STORAGE, AND ANALYSIS PROCEDURES

Previous sections of this chapter have indicated that data recording, storage and analysis procedures are required so that data obtained from each of the four component techniques can be integrated together in order to form a large information base that is capable of assessing the extent of misuse, so that compliance strategies can be developed and eventually evaluated.

The data recording procedures should be developed utilizing standardized forms. These forms must be designed so that the information required to assess the extent of misuse (as described in Exhibit 11) is recorded. Moreover, information required to match the same misuse event uncovered by different misuse measurement component techniques, such as the date and location of the misuse, must also be recorded on these forms. Currently, a variety of forms are being utilized by both the Federal EPA and various states and these were shown in previous exhibits in this chapter. However, none of these forms are designed so that all the information outlined in Exhibit 11 can be recorded on the form, if available. Consequently, modification to existing forms and/or development of new recording forms will be necessary to implement the PLAINS.

Once the data are collected and recorded on standardized forms, the information must then be coded into machine readable form for easy storage and access. This process will also facilitate the integration of data from the four component techniques (i.e., data from different techniques can be easily matched by using identifying information such as the date and location of the misuse event). Coding the information into machine readable form will require the development of coding schemes. Existing coding schemes and procedures (e.g., those used in the PERS) can be utilized or additional procedures can be designed. For example, the various taxonomies presented in Chapter 2 can be used as alpha-numeric coding schemes to code various types of information about misuses cases (e.g., pesticide class, method of use, misuse type, applicator/application type, health and environmental damages, factors leading to misuse) into machine readable form Moreover, alphabetic codes can be used (e.g., to code misuse locations by using the two letter state abbreviations) and numeric codes can be used (e.g., to designate the date of the misuse occurrence). Consequently, the development of coding schemes should not be problematic since the issues involved are well known and have been overcome in previous efforts. Storing the machine readable data can be accomplished by using computer punch cards or by using remote terminals for data entry.

The data analysis will be eased since all data generated by each of the four component techniques will be contained in one information system. Various frequency counts can be made on single variable dimensions such as:

- Type of misuse;
- Type of pesticide class involved;
- Type of applicator/application type involved;
- Type of method of use involved;
- Type of effects involved; and
- Type of factors leading to misuse involved.

Multi-dimensional cross tabulations can also be generated to determine key relationships such as what factors lead to given misuse types, what effects are caused by given misuse types, what applicator/application types are associated with given misuse types and what factors lead to certain applicator/application types to misuse pesticides.

Moreover, the data analysis can attempt to generate a pesticide misuse damages model of the form:

y = f(month, county, crop, pest, pesticide, type of misuse,
factors leading to misuse)

where y = a measure of damages due to misuse* and the other variables account for some component of damage variance. If the independent variables are selected to include only quantifiable continuous variables (as opposed to variables such as month, county, crop, pest, etc.) then a multiple regression technique may be applicable, e.g.,

$$y = a(\text{acres treated}) + b(\text{crop value}) + c(\text{education}) + d(\text{age})$$

where y is the variable for damages due to misuse.* In any case, the independent variables should be analyzed to determine the best possible explanatory variables for misuse damages.

The end result of this data analysis will be a detailed picture (i.e., information profile) of each misuse type at a specified point in time, as well as a model predicting the type of damages from specified misuses and other associated characteristics. Consequently, the PLAINS will provide a broad information base for the development of monitoring and compliance strategies, and for guiding the allocation of resources in achieving reduced misuse.

In its eventual use, the PLAINS must also provide evaluation of compliance strategies, and the ability to tailor strategies such as incentives, education and citations.** Thus, the PLAINS must report the types of misuse where economics of production, complexity of technology and deliberate circumvention of law are factors.

However, the data and techniques of the PLAINS will need careful implementation and a gradual buildup of cases and episodes (using PERS information, if' desirable). The four basic component techniques of the PLAINS will need, first, pilot implementation, followed by review, analysis, and interpretation. Although the PLAINS is a next logical step in the use of information systems such as APHIS, PERS, STORET, and ENVIRON, it should not become a large massive duplication of data files and compilation effort. That is, although the special requirements of using the misuse measurement technique to devise compliance strategies will require certain specialized files, analyses and models, existing data files and information systems should be utilized or adapted whenever possible.

SUMMARY

Interrelationship of PLAINS Techniques

Previous sections of this chapter have described four different techniques comprising the PLAINS for measuring adherence with pesticide label requirements.

*For possible damages measures to use, refer back to the discussion in the Pesticide Use Observation, Detection of Misuse and Methods of Data Generation subsection (see page 66).

**"Tailoring" compliance strategies implies that the strategy is directed precisely at the misuse event and the related user actions. An extension of this tailoring concept to the idea of a behavior model is presented in Chapter 5.

These are pesticide use observations, user audit, damages monitoring and, residue monitoring. As indicated above, each may be used separately, but more likely would be used in conjunction with one another.

For example, monitoring health and environmental damage reports or pesticide residue reports may indicate that a pesticide misuse has occurred. However, if the information contained in these reports is somewhat sketchy, a complete understanding of the possible pesticide misuse (e.g., the type of misuse, the pesticide/applicator/use situation (PAU) involved, the severity of the damage and the factors leading to the misuse), would not be discernable. Consequently, the misuse investigator may want to follow up the report with a more detailed investigation. That is, based upon the information contained in the damage report or residue studies, pesticide user audits with appropriate pesticide users (i.e., those users associated with the pesticide/applicator/use combination in question) may be desirable. Moreover, selected use observations performed in a random manner may also be worthwhile.

As a separate effort, use observations should be performed independent of any information extracted from health and environmental damage reports or pesticide residue reports by utilizing information generated from the ranking system for pesticide misuse (Chapter 3). Similarly, pesticide user audits should be performed based upon the various types of pesticide usage reports available to the misuse investigator.

A number of factors will eventually dictate the exact nature of the PLAINS (Pesticide Label Adherence Information System) to be adopted by a particular pesticide regulatory and/or enforcement agency. In other words, the ability to integrate all four measurement techniques will be a function of:

- Available data sources;
- Available financial resources and manpower;
- Goals and purposes of the regulatory and/or enforcement agency vis-a-vis detecting and exploring pesticide misuse;
- Legal constraints of the regulatory and/or enforcement agency; and
- Political pressures put upon regulatory and/or enforcement agencies.

The Working Group on Enforcement of the State-Federal FIFRA Implementation Advisory Committee (SFFIAC) has developed and circulated a State Enforcement Matrix (see Appendix A) to all states requesting information on these various factors. Once this survey is completed and analyzed, this information will provide much information concerning the feasibility of implementing the PLAINS procedure at the state level. The feasibility of using the procedure at the Federal EPA regional and headquarters level can best be determined by EPA regulatory and enforcement personnel.

Relationship Between the PLAINS and Current Misuse Measurement Activities

As indicated in the overview, the Federal EPA and many states prevently have in place a network of personnel for responding to and investigating incidents of misuse of pesticides. This network includes local, state and regional investigators, as well as EPA personnel at the headquarters level, i.e., the Pesticide Misuse Review Committee (PMRC). The procedures used by Federal EPA are well established and are described in the Pesticides Inspection Manual provided by the Pesticide and Toxic Substances Enforcement Division (PTSED)/EPA. These investigators apply standard techniques, both in making routine visits as well as in responding to complaints or reports of possible misuse.

These standard techniques result in investigative reports which, together with lab analysis and affidavits from observers, serve either as the basis for citations of users issued pursuant to Section 14(a)(2) of FIFRA, as amended, or as the basis for originating legal action intended to lead to civil or criminal penalties.

In addition to the investigation of potential misuse described above, data on possible misuse is generated in many other forms, such as hospital records, poison control center forms, wildlife, soil and water residue monitoring, and the Pesticide Episode Reporting Forms (PERF's) comprising the PERS.* These data sets are not an integral part of the investigative network, although they provide general information on types of misuse, if the information provides a basis for deciding that some misuse actually occurred.

In the case of wildlife residue monitoring, for example, residues can conceivably build up in animals (bioaccumulation) even though no extraordinatry spills or other misuses have occurred. Similarly, runoff from farms into streams could possibly reach concentrations lethal to fish, even though no label violations had occurred. What is missing from these data systems are direct connections between documented misuses and related environmental damages.

The pesticide misuse investigation procedures used by the EPA investigators do in fact provide a direct connection between misuse and some environmental damages. The case reports produced by these investigations provide basic data on misuse-related actions and events and the immediately available damage observations, obtained from on-scene observers and from lab analysis of samples taken "on-the-spot".

The proposed misuse measurement system (PLAINS) would integrate similar types of data. The investigator reports could thus be complemented, as well as supplemented by the PLAINS measurement data. A much larger baseline data set would be compiled and accumulated than is now possible with the investigator reports alone. The misuse data compiled would be linked by common variables to the other data bases, such as USDA/APHIS, PARCS, PERS, and the FDA system. The investigators would be able to use this PLAINS data base conveniently to assess the compliance strategies proposed or currently in use.

*These sources were termed "remote input data" in Exhibit 12.

Previous pilot studies and state efforts* provide additional guidelines for the development and use of this system. For example, various pilot studies to collect physician reports of treatment of pesticide poisoning cases** have shown that such a system is feasible, providing that it meets certain simple criteria, e.g.,

- The staff develops direct contact and rapport with physicians who are collecting the data; and

- The data obtained are not intended for use as the basis for misuse citations or legal action.

Hence, the PLAINS system would not be intended to be utilized directly by an enforcement agency as the basis for legal action. Further investigation by an enforcement official would be required.

However, the investigators would not have to complicate their present investigation procedures by adding the PLAINS technique to what they are already doing. That is, the PLAINS technique can be implemented by a separate staff, if desired, who can work continuously, and who need not "double" as an immediate response staff for misuse reports and complaints. Thus, the proposed PLAINS system would not be intended to be applied directly by an investigator following a misuse report. Although the same misuse event might be added to the PLAINS data base, the data would be collected by a separate researcher, or it might come from the original investigator's report, depending on the complexity of the damages and causes.

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*For example, PTSED pilot enforcement grants in California, Washington, North Carolina, Maine and Hawaii.

**For example, EPA/OPP/Operations Division funded studies in various states such as Alabama, Arkansas, California (Fresno County), Kentucky, Illinois, Maine, Montana, New Mexico, North Carolina, Ohio, Oklahoma, Oregon, Pennsylvania, South Dakota, Tennessee (Shelby County).

CHAPTER 5

TOWARDS A BEHAVIOR MODEL OF PESTICIDE MISUSE

INTRODUCTION

In this chapter, a model explaining why users misuse pesticides is presented. In other words, those factors that contribute to pesticide misuse occurrences are delineated.

The importance of knowing what contributes to a user misusing a pesticide is brought about because the identification and evaluation of alternate compliance strategies intended to reduce misuse and to encourage compliance with label restrictions on pesticides, is a central objective of the contract. There are many implications within the idea of a compliance strategy, but one of the more crucial implications is that pesticide misuse involves human behavior and human error, and some kind of behavioral change is essential to any reduction of pesticide misuse, i.e., to the improved adherence to pesticide label restrictions.

Consequently, in order to gain insights into the human behaviors and human errors associated with the pesticide misuse occurrences, the pesticide misuse cases reviewed by the Pesticide Misuse Review Committee (PMRC) were used to form the basis of a "case study", as this existing data set on pesticide misuse provided the most detailed information for any particular pesticide misuse case. More specifically, a detailed review of the first two hundred PMRC misuse cases was made, primarily relying upon the PMRC summary of the misuse case and, in many instances, additional memos submitted by the investigating officer. Exhibit 20 outlines the types of data that were extracted during this review process.

As indicated in the exhibit, much more information than just the factors contributing to the misuse was recorded and, in fact, the various taxonomies delineated in Chapter 2 were used to code particular pieces of information about each misuse case.* Only CONSAD staff were involved in this data extraction and coding process; thus, the information extracted and coded are implicitly based upon the CONSAD staff's interpretation of each case. Hence, the validity of the various codes assigned to each case has not been tested. Nevertheless, the application of the coding procedures to the PMRC cases was a preliminary test to assess the viability of the coding procedures as a basis for behavior factors models of pesticide misuse and for suggesting ideas for compliance strategies.

*More accurately, preliminary versions of these taxonomies underwent revision as a result of reviewing the PMRC cases. In essence then, the taxonomies, as they now appear, somewhat evolved as a result of this review process.

Exhibit 20: Data Extracted from PMRC Misuse Cases

- Date of misuse occurrence;

- Location of misuse occurrence, i.e., City, County, State, Federal Region;

- Pesticide/Applicator/Use Situation Involved;
  - Pesticide involved;
    - product name, active ingredients, and pesticide class;*
    - toxicity data, if available;
    - amount dispersed, e.g., dilution rate, application rate of diluted material and active ingredient;
  - Type of applicator involved;**
  - Use situation e.g., site of application (including size) and pest involved;

- Method of use involved, e.g., transport, mixing, loading application, storage, disposal, etc;***

- Type of misuse committed;****

- Health or environmental effects, i.e., severity of damages;*****
  - Type and number killed;
  - Type and number ill or damaged;
  - Type and number contaminated and level of contamination;
  - Dollar value of damage, if given;

- Factors leading to misuse, i.e., cause;****** and

- Additional information, if deemed pertinent.

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*As specified in Taxonomy of Pesticide Classes (Exhibit 3).

**As specified in Taxonomy of Applicator/Application Types (Exhibit 4).

***As specified in Taxonomy of Methods of Use (Exhibit 5).

****As specified in Taxonomy of Pesticide Misuse (Exhibit 2).

*****As specified in Taxonomy of Potential Health and Environmental Effects (Exhibit 6).

******As specified in Taxonomy of Factors Leading to Pesticide Misuse (Exhibit 7).

Exhibit 21: Taxonomy of Factors Leading the Pesticide Misuse
(Major categories and first level of subcategories)

1. Motivation to Misuse Pesticides
   A. Economic Incentives
   B. Pride
   C. Institutional Constraints

2. Physical/Psychological Condition of User
   A. Fatigue
   B. Illness
   C. Psychological State of User

3. Physical Ability of User
   A. Age
   B. Physical Weakness
   C. Physical Disability
   D. Visual Disability

4. Training
   A. Basic Educational Lack
   B. Ignorance About Pesticides
   C. Carelessness or Negligence

5. Intervening Social Conditions
   A. Local Custon
   B. Habit

6. Intervening Natural Conditions
   A. Windstorm
   B. Rainstorm
   C. Excessive Heat or Cold
   D. Drought
   E. Infestations
   F. Malfunction of Equipment
   G. Other

7. Product Label Deficiency
   A. Deficient Precautionary Statement
   B. Deficient Restrictions
   C. Deficient Use Instructions
   D. Other

In addition to reviewing and extracting information from the PMRC misuse cases, a variety of other activities were also undertaken to gain insights into the various antecedents to pesticide misuse; e.g.:

- A literature review of human performance and human factors research;
- An analysis of the data extracted from the PMRC misuse cases;
- Interviews with Consumer Safety Officers from EPA Region IV who investigated many of the PMRC misuse cases;
- Refinement of the taxonomy of factors leading to pesticide misuse and development of a behavior factors model of pesticide misuse; and
- A flow chart analysis for a common pesticide use process.

The results of these activities are presented in the remaining sections of this chapter (the literature review is presented in Appendix B).

BEHAVIOR MODEL OF PESTICIDE MISUSE

Need for a Taxonomy of Factors Leading to Pesticide Misuse

Motivational psychology has traditionally been the gathering place of occult concepts such as "drives", "needs", and "corporate organizations". If, as in the present pesticide misuse context, it is desirable to use more every day terms, in order to identify the antecedents of misuse, it is difficult to avoid the conenvient constructs, such as "habit", even though they do not immediately lead to detailed behavior level compliance strategies. Thus, the development of successful compliance strategies will depend on detailed behavior models (which in turn depend on observable behavior sequences and background data) and on operational concepts which help to connect the misuse event to these (independently) observable behavior sequences and background facts.

The difficulty of selecting an appropriate set of concepts for the behavior model is illustrated by the concept of "just plain carelessness", which is used more commonly and with greater finality than "carelessness" alone. Various people* who have been contacted in the present pesticide misuse project have suggested that many pesticide misuse occurrences have been caused by, due to, or partly generated by "just plain carelessness". This phrase is intended to identify the precursory behavior factors leading to the misuse.

*Included are EPA Consumer Safety Officers and state Pesticide Enforcement Officials.

But difficulty is encountered in elaborating on the details of why and how the "just plain carelessness" occurred. And the concept does not identify specific detailed behavior sequences which could be pinpointed to enable misuse reduction.

Components of the Taxonomy of Factors Leading to Pesticide Misuse

These needs and requirements have led to the notion of a taxonomy of factors which lead to pesticide misuse. There are two assumptions underlying the taxonomy approach, i.e.:

- The actual types of behavior leading to pesticide misuse are complex, varied, and numerous; and
- A given misuse occurrence probably has more than one identifiable, contributing behavior factor.

Using these two assumptions, a taxonomy has evolved, based on seven major factors:

- Motivation to Misuse Pesticides;
- Physical/Psychological Condition of User;
- Physical Ability of User;
- Training of User;
- Intervening Social Conditions;
- Intervening Natural Conditions; and
- Product Label Deficiency.

The last two factors are not types of behavior but are external conditions beyond the control of the user. Nevertheless, these factors stimulate distinctive kinds of behavior, and distinctive kinds of pesticide misuse. The other five factors represent an attempt to derive a directly applicable set of concepts from psychological theory. The analogous constructs would be:

- Cognition-mental set;
- Short-term physiological and emotional state;
- Medical and long-term physiological state;
- Learning; and
- Peer group and social network inputs.

Some of these five categories (i.e., factors) overlap, and the operational measurement of them in a pesticide use context is not typically done. Nevertheless, these five categories represent a broad scope of possible misuse antecedents, and it should be possible for any investigator or other misuse specialist to understand and relate to them, after a small amount of explanation.

Thus, the basic components of the taxonomy are the categories of behavior which lead to misuse. These broad categories -- motivation to misuse, physical/psychological conditions, etc. -- are broken into more specific subcategories in order to arrive at specific contributing antecedents of misuse. In other words, the more detailed subcategories are specific factors which make up the general categories of misuse factors.

The first level of subcategories is shown in Exhibit 21. This table shows how the subordinate categories add detail and specificity to the major headings. The reader will note that under the first set of factors (i.e., motivation to misuse pesticides) a subset (factor 1C) has been labelled institutional constraints. These factors deal with events in the institutional setting that are to a large extent beyond the control of the user, but nevertheless, motivate the user to misuse pesticides. Furthermore, user constraints (factor 1D) primarily represent financial expenditures beyond the resources of the user, which again, motivates him (or her) to misuse pesticides. Misuses resulting from factors 1A and 1B can be viewed as volitional misuses (i.e., willful violation of the label), as can misuses from factor 4C, and to some extent, misuses from factors 5A and 5B. Misuses resulting from many of the remaining factors, e.g., 2A, 2B, 3A - 3D, 4A and 4B, can be viewed as nonvolitional misuses.

Further detail can be added to these first level subcategories as is shown in the fully developed taxonomy (see Exhibit 22*). The categories become more and more <u>specific</u>, but they keep their applicability to <u>many</u> pesticide misuse occurrences, i.e., their ability to identify the antecedent conditions of a given <u>set</u> of misuse events.

<u>Uses of the Taxonomy</u>

The factors taxonomy has immediate usefulness as an aid to analyzing and understanding misuse events. Thus, the taxonomy will be useful to investigators and PMRC officials as a guide to understanding how a misuse situation develops and evolves. Even though it is not used to reach a final opinion or classification of a given misuse case, it can serve as a guide for discussion and review, to develop a behavior scenario for the case and, to assess the various antecedent and contributing conditions and events.

In addition to this usefulness as a review and discussion technique and tool, the taxonomy provides an approach to the statistical analysis of the behavior involved in misuse. The taxonomy in its present form provides a basis for measuring the various contributing conditions and antecedents in leading to misuse. Thus, the role of economic pressures, training and attention can be measured in the occurrence of a misuse event.

*The reader will note that Exhibit 22 is the same as Exhibit 7. The exhibit is again presented here for ease of readability.

Exhibit 22: Taxonomy of Factors Leading to Pesticide Misuse

Type 1 Factors: Motivation to Misuse Pesticides

A. Economic incentives (i.e., to user's self interest)
  1. For "not for hire" applicators
    a. Crops, agricultural commodities, etc.
      1. higher yields can be obtained or are sought
      2. lower crop production costs (i.e., pest control costs) can be obtained or are sought
      3. meet harvest deadlines
      4. meet market fluctuations
      5. other
    b. Non-agricultural use situations
      1. the "best" control of the pest problem can be obtained or is sought (e.g., eliminate pest species "once and for all")
      2. lower pest control costs can be obtained or are sought
      3. other
  2. For "for hire" applicators
    a. Crops, agricultural commodities, etc.
      1. desire to reduce cost, time and/or complexity of pest control operation (e.g., by limiting the number of different pesticides used, by encouraging use of particular pesticides, etc.)
      2. desire to increase sales (e.g., desire to please the customer)
      3. other
    b. Non-agricultural use situations
      1. desire to reduce cost, time and/or complexity of pest control operation (e.g., by limiting the number of different pesticides used, by encouraging use of particular pesticides. etc.)
      2. desire to increase sales (e.g., desire to please the customer)
      3. other

B. Pride
  1. Importance of aesthetic quality (e.g., "perfect" golf green, garden, shrubs, lawn, etc.)
  2. Importance of high yields

C. Institutional constraints.
  1. No registered pesticide exists for use situation
  2. Registered pesticides for use situation not available (i.e., sold out)
  3. Proper equipment cannot be obtained (e.g., no equipment outlet, equipment will not be supplied by employer)
  4. Knowledgeable experts not available (e.g., incorrect advice received from extension service)
  5. Proper disposal sites not in existence
    a. Payoffs from manufacturers or wholesalers for selling specific pesticides
    b. Excessive desire to boost sales, move high quantities
    c. desire to simplify stock by reducing variety of materials sold
    d. desire to reduce storage of leftover materials and to reduce material and container disposal costs
  7. Other

D. User constraints (i.e., user cannot afford to adhere to label requirements although he may know it is not his self interest)
  1. Protective clothing too expensive
  2. Proper application equipment cannot be afforded
  3. Proper maintenance of application equipment cannot be afforded, i.e., use of faulty equipment
  4. Other

Exhibit 22: Taxonomy of Factors Leading to Pesticide Misuse (Continued)

Type 2 Factors: Physical/Psychological Condition of User

A. Fatigue (e.g., "over worked")
B.
  1. Effects of weather
  2. Effects of pesticide exposure
  3. Other
C. Psychological state of user
  1. Mental illness
  2. Mental attitude
     a. willful disregard for environmental protection or safety of human health
     b. hatred for employer, job, neighbor, etc.

Type 3 Factors: Physical Ability of User

A. Age - too old or too young to properly use pesticides
B. Physical weakness
C. Physical disability (e.g., lacked use of hands, arms, etc.)
D. Visual disability

Type 4 Factors: Training of User

A. Basic educational lack
  1. Low general education
  2. Cannot follow directions
  3. Cannot read well (e.g., cannot understand use instructions or precautionary statements)
B. Ignorance about pesticides
  1. Lack of experience (e.g., "new on the job")
  2. Lack of proper supervision for inexperienced personnel
  3. Not trained adequately in basic pesticide use practices
  4. Not trained adequately to use particular pesticides
  5. Not aware that use inconsistent with labeling is a violation of Federal law (i.e., Section 12(a) (2) (G) of FIFRA, as amended)
C. Carelessness or negligence
  1. Precautionary statements not fully read, forgotten or not taken seriously
  2. General organizational failure in specifying tasks and precautions (e.g., lack of teamwork and coordination)
  3. Failure to distinguish among two or more pesticides leading to improper generalization of procedures or precautions
  4. Failure to request necessary assistance
  5. Other

Type 5 Factors: Intervening social conditions

A. Local custom (e.g., many people have done it repeatedly over time
B. Habit (e.g., individual applicator has done it repeatedly over time

Type 6 Factors: Intervening natural conditions

A. Sudden windstorm
B. Sudden rainstorm
C. Unforeseen and excessive temperatures (too hot or too cold)
D. Unforeseen and excessive drought
E. Unpredictable infestations
F. Sudden malfunction of application equipment (e.g., faulty equipment design)
G. Other

Type 7 Factors: Product Label Deficiency

A. Precautionary statements not sufficient to prevent potential adverse effects
B. Restrictions and limitations not sufficient to prevent potential adverse effects
C. Use instructions not sufficient to insure proper use (e.g., FIFRA Section 12(a)(2)(G) warning does not appear on the label)
D. Other

As a further analytical technique, the frequency of the various behavior factors as a statistical phenomenon can provide policy inputs for misuse reduction strategies. These frequency statistics, when calculated for a large sample of misuse cases, provide a larger view of what misuse events have in common in terms of the human errors and misjudgments which have led to them. This statistical approach is developed further below, where the PMRC misuse cases are reviewed.

Use of the Taxonomy in Behavior Modeling

A further use of the taxonomy in Exhibit 22 is as a basic structure for the development of behavior models of misuse. As a further development of the uses described above, the behavior model approach develops the analysis of misuse behavior along formal, precise directions, with emphasis on exactly defined measurement of the misuse events, the behavior involved, and the subsequent effects and damages. The modeling approach, in other words, insists on the operational definition of the variables involved in misuse.

Behavioral models are models based on a sequence of individual person actions in a defined economic-demographic context. Specific economic-demographic contexts in which such models have been applied include:

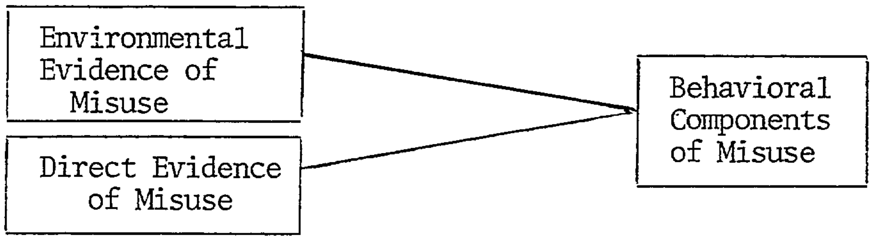
- Residential choice;
- Family formation; and
- Migration.

A behavior model for pesticide misuse now appears to be necessary in order to fully understand how and why particular types of misuse occur, so that finely tuned compliance strategies for pesticide misuse can be developed.

A number of compliance strategies have been devised in a variety of state enforcement projects, but these strategies are sometimes difficult to connect with specific events and actions which involve misuse (label violations). These compliance strategies include special interviews with users, checks of safety procedures during application, and inspections of equipment. In other words, the checks of safety procedures are an important educational effort, but formal knowledge of how these strategies relate to the antecedent behavior and subsequent effects is needed.

In order to tailor compliance strategies precisely to the types of misuse which are most common and/or most damaging, it will be necessary to develop and use for analysis purposes a theoretically based model which relates the actions and behavior involved in misuse to the measure of misuse. The most obvious measure of misuse is its frequency of occurrence, but statistical development of a behavior model should enable the connection of behavioral background factors to measures of misuse scope and damages. As noted above, the behavior modeling approach insists on the operational definition of all concepts and variables.

It is useful to segment the types of information which will need to be measured:



In the above diagram, the evidence of misuse is divided into two pieces: environmental evidence and direct evidence. Dividing a very mixed set of information, such as misuse evidence, into two arbitrary categories usually leads to chronic confusion, but in this case, the division indicates the various approaches available for measuring the extent of misuse. The two approaches defined here are measuring pesticide residues and environmental damages which probably came about because of misuse; and measuring direct evidence of misuse during application or other procedures. Direct evidence includes spilled containers, dispersal by wind drift, soil and water runoff, and actual observation of improper practices.

The two part division of evidence suggests two kinds of predicted variables for use in a behavior model.

Y_1 = environmental and human health damages

Y_2 = scope of misuse event

These two variables overlap, but the distinction could be useful in developing and testing alternative behavior models. The form of such models could be:

Y_1, Y_2 = f(motivation, physical/emotional conditions, training, physical ability, intervening social conditions, intervening natural conditions, label deficiency).

The human performance factors on the right hand side of this model are those defined in the taxonomy in Exhibit 22.

It should be emphasized that the above human performance factors overlap, and that no single event of misuse is likely to arise from a single behavior factor. Thus, an application of improper dosage could arise partly from motivation and partly from lack of training. The tailoring of compliance strategies will depend on the weight each performance factor carries in contributing to the misuse. A procedure for assessing these weights must be applied in order to obtain adequate data for a complete formal behavior model.

In order to understand how the development of a behavior model could be pursued, it is helpful to think of the arrangement of statistical data in a table format (Exhibit 23). Such a table suggests that a misuse "experiment"

Exhibit 23: Table Format for Behavior Model Development

Factor 2 \ Factor 1		Lack of Training: Highly Important	Lack of Training: Not Important
Economic Incentives	Highly Important	d_{ij}, m_{ij}	d_{ij}, m_{ij}
	Not Important	d_{ij}, m_{ij}	d_{ij}, m_{ij}

d_{ij} = measures of damages from misuse events

m_{ij} = measures of misuse such as scope, quantity, or toxicity

has been conducted with measurements of misuse and damages having been taken under controlled conditions. Thus, the table is for discussion purposes only.

Furthermore, the table relies on the measurement of the "importance" of various behavior factors in their contribution to a set of misuse cases. The table illustrates two "levels" of importance, but more levels could be defined, if the taxonomy were applied to a series of case analyses. The table drawn serves to illustrate a stage in the behavior model development.

If such data were available, then appropriate statistical techniques could produce solutions to the linear equation:

$$d_{ij},\ m_{ij} = a(\text{economic incentives}) + b(\text{lack of training}) + c$$

At present, data are not available to conduct such an analysis, and there are two reasons why further basic work is necessary before such analysis would be appropriate:

- The factors taxonomy requires further refinement; and
- The taxonomy, as it is now, is a useful tool, and will become more useful as it is refined.

Thus, a completely developed behavior model is both not available, as well as inappropriate at this time.

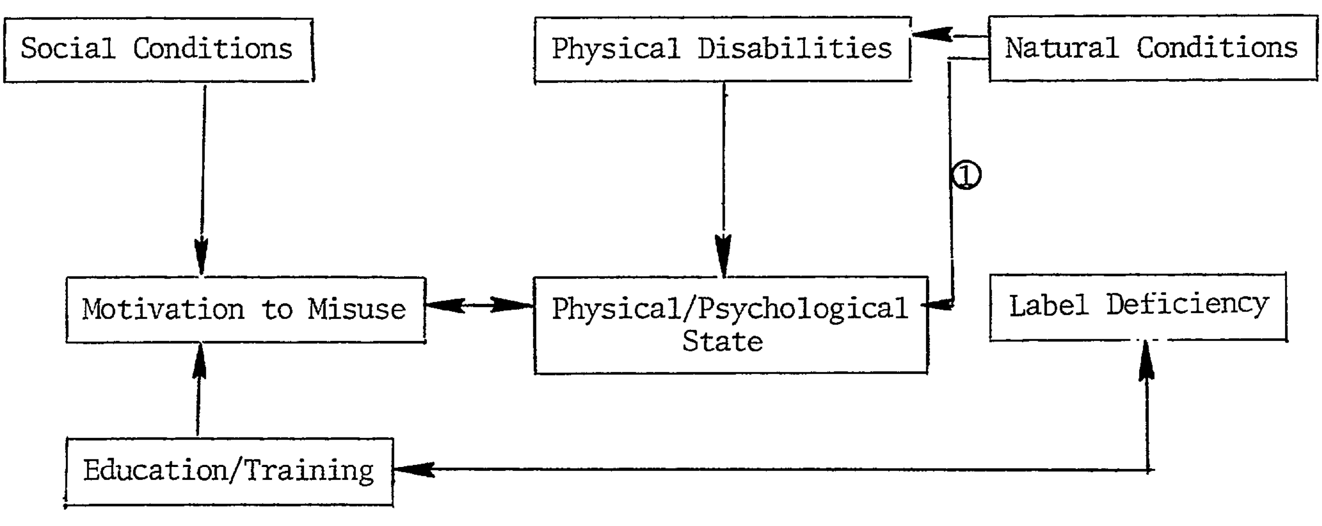
A further problem in behavior modeling of the type discussed here is that some of the behavior factors (dependent variables) may influence each other, and the structure of such influence is useful to hypothesize before doing extensive analysis (see Exhibit 24). The lines among behavior factors in Exhibit 24 represent tentative hypotheses about how various behavior factors might interact and intermix to lead to increased misuse or more severe effects. Thus, a user's psychological state could be further influenced by natural conditions such as heat and rain to produce a misuse which might not have occurred otherwise (line 1). Similarly, social conditions such as the weight of local tradition could add to an economic or personal pride motive and lead to a misuse which the user's education and training would otherwise have prohibited.

In summary, the basic structure of a behavior model for pesticide misuse has been described in terms of four components:

- A behavior factors taxonomy;
- Data on misuse and effects;
- Data on importance and weights of behavior factors; and
- Hypotheses and analysis of internal model structure.

Discussion and description of each component was presented, but the final development of the model is still pending. The factors taxonomy itself is still open to improvement in terms of both logical structure, and behavior theory. The most important next step towards behavior modeling is to use the factors taxonomy in analyzing misuse cases, so that its use, techniques, and statistical quality become fully developed.

Exhibit 24: Possible Structure of Behavior Factor Influences on One Another



PMRC Misuse Case Review Inputs

The analysis of the data extracted from the PMRC misuse cases provided a number of useful insights concerning the taxonomy of factors leading to pesticide misuse, as well as other dimensions of pesticide misuse.

Exhibit 25 presents a tabulation of those factors most often recorded to describe why a pesticide misuse occurred. The frequency for each factor is broken down into two categories - those that the CONSAD staff were fairly certain led to a misuse and those that the CONSAD staff thought may have led to misuse. The reader will note that the total number of factors recorded exceed the number of PMRC cases reviewed (i.e., 192) because many cases involved multiple factors. Consequently, the last column of the exhibit presents information concerning the percent of all cases in which each factor appeared. The most noticeable factors leading to pesticide misuse were those involving ignorance (factor 4B), carelessness or negligence (factor 4C) and, economic incentives (factors 1A1b and 1A1c).

Exhibits 26 through 30 present similar tabulations for other variable types, i.e., misuse, effect, method of use, applicator/application type and, pesticide.

Cross-tabulations for various combinations of variables are presented in Exhibits 31 through 36 as follows:

- Exhibit 31 - Cross-tabulations of pesticide misuse and effects of pesticide misuse;
- Exhibit 32 - Cross-tabulations of pesticide misuse and factors leading to pesticide misuse;
- Exhibit 33 - Cross-tabulation of applicator/application type and factors leading to pesticide misuse;
- Exhibit 34 - Cross-tabulation of pesticide and pesticide misuse;
- Exhibit 35 - Cross-tabulation of applicator/application type and pesticide misuse; and
- Exhibit 36 - Cross-tabulation of method of use and pesticide misuse.

In each exhibit, the most significant combinations have been designated by an "X" in the appropriate cells. For example, in Exhibit 31, the key misuses and the associated effects are presented. Thus, this exhibit indicates the types of misuse that must be reduced in order to reduce various types of environmental damage. Exhibit 32 indicates the key factors that were indicated as leading to the misuses, and consequently, some necessary background information for designing cost-effective compliance strategies. Additional information for compliance strategies could be obtained from Exhibit 33 through 36 which provide further insights into why different applicators misuse pesticides (Exhibit 33)

Exhibit 25: Tabulation of Key Factors Leading to Pesticide Misuse Involved in PMRC Misuse Cases

Factors Code*	Frequency			Percent of All Factors Codes Recorded	Percent of All Cases in Which Code Appeared
	Total	Certain	Uncertain		
4C	117	106	11	22.41	60.94
4B	100	97	3	19.16	52.08
1A1a	60	54	6	11.49	31.25
1C	44	35	9	8.43	22.92
5B	26	26	0	4.98	13.54
2C2a	24	16	8	4.60	12.50
1A1b	23	19	4	4.41	11.98
6	23	18	5	4.41	11.98
7	22	13	9	4.21	11.46
Not Applicable	22	22	0	4.21	11.46

*As specified in Exhibit 7 or Exhibit 22.

Exhibit 26: Tabulation of Key Pesticide Misuse Types Involved in PMRC Misuse Cases

Misuse Code*	Frequency			Percent of All Misuse Codes Recorded	Percent of All Cases in Which Code Appeared
	Total	Certain	Uncertain		
9C	52	43	9	13.83	27.08
2A	41	39	2	10.90	21.35
9E	39	33	6	10.37	20.31
4	35	27	8	9.31	18.23
6A	31	25	6	8.24	16.15
2D	30	28	2	7.98	15.62
3A	20	18	2	5.32	10.42
9A,B,D,G,H	20	18	2	5.32	10.42
7	16	13	3	4.26	8.33
10B	16	15	1	4.26	8.33
6B,C	15	14	1	3.99	7.81
None	22	22	0	5.85	11.46

*As specified in Exhibit 2.

Exhibit 27: Tabulation of Key Effects of Pesticide Misuse Types Involved in PMRC Misuse Cases

Effects Code*	Frequency			Percent of All Effects Codes Recorded	Percent of All Cases in Which Code Appeared
	Total	Certain	Uncertain		
2	41	27	14	11.82	21.35
5B	38	28	10	10.95	19.79
1	34	20	14	9.80	17.71
4C	20	12	8	5.76	10.42
5A,C,D,E	18	13	5	5.19	9.38
5G	18	15	3	5.19	9.38
6A	18	16	2	5.19	9.38
3A	16	10	6	4.61	8.33
4A,B,D,E	14	9	5	4.03	7.29
5H	13	10	3	3.75	6.77
5F	12	12	0	3.46	6.25
3B	10	8	2	2.88	5.21
6B,C,E,G,H	10	5	5	2.88	5.21
6F	10	5	5	2.88	5.21
None	74	74	0	21.33	38.54

*As specified in Exhibit 6.

Exhibit 28: Tabulation of Key Method of Use Types Involved in PMRC Misuse Cases

Method of Use Code*	Frequency			Percent of All Method of Use Codes Recorded	Percent of All Cases in Which Code Appeared
	Total	Certain	Uncertain		
4A	60	60	0	27.40	31.25
4B2,4,5,7,8, 9,11,12,13	38	38	0	17.35	19.79
4B1a	34	34	0	15.53	17.71
4B1b	24	24	0	10.96	12.50
4B3	14	14	0	6.39	7.29
4B10	14	14	0	6.39	7.29

*As specified in Exhibit 5.

Exhibit 29: Tabulation of Key Applicator/Application Types Involved in PMRC Misuse Cases

Applicator/ Application Type Code*	Frequency			Percent of All Applicator/ Application Type Codes Recorded	Percent of All Cases in Which Code Appeared
	Total	Certain	Uncertain		
1F	53	53	0	26.50	27.60
8F	32	32	0	16.00	11.67
1A,B	24	24	0	12.00	12.50
8D,E	15	15	0	7.50	7.81
9G	10	10	0	5.00	5.21
4F	9	9	0	4.50	4.69
7G	6	6	0	3.00	3.12
1E	5	5	0	2.50	2.60
4D,E	4	4	0	2.00	2.08
6G	4	4	0	2.00	2.08
5E	4	4	0	2.00	2.08

*As specified in Exhibit 4.

Exhibit 30: Tabulation of Pesticides Involved in PMRC Misuse Cases

Pesticide	Frequency			Percent of All Pesticide Types Recorded	Percent of All Cases in Which Pesticide Type Appeared
	Total	Certain	Uncertain		
Insecticides	132	132	0	52.59	68.75
Herbicides	68	68	0	27.09	35.42
Fungicides	16	16	0	6.37	8.33
Other*	13	13	0	5.18	6.77
Bird Poisons and Repellents	11	11	0	4.38	5.73
Rodenticides	11	11	0	4.38	5.73

*Includes antimicrobial agents, fish poisons and repellents, invertebrate animal poisons and repellents, mammal poisons and repellents, plant regulators, and slimicides.

Exhibit 31: Cross-Tabulation of Variables Pesticide Misuse and Effect of Pesticide Misuse
(X's designate the most significant combinations of the two variables specified)

Misuse Code*	Effects Code**														
	1	2	3A	3B	4A,B,D,E	4C	5A,C,D,E	5B	5F	5G	5H	6A	6B,C,E,G,H	6F	None
2A	X	X	X				X	X	X	X			X	X	X
2D	X	X		X				X	X	X		X	X	X	X
3A	X	X	X		X			X		X					X
4	X	X			X	X		X	X	X	X				X
6A	X	X		X	X					X		X	X		X
6B,C	X	X			X	X		X			X				X
7	X	X													X
9A,B,D,G,H			X	X	X	X		X			X	X	X	X	X
9C	X	X	X	X	X	X	X	X	X		X	X	X	X	X
9E		X	X		X	X	X	X	X	X	X	X		X	
10A	X	X		X									X		
10B			X		X	X		X							X
None			X				X								X

*As specified in Exhibit 2.
**As specified in Exhibit 6.

Exhibit 32: Cross-Tabulation of Variables Pesticide Misuse and Factors Leading to Pesticide Misuse
(X's designate the most significant combinations of the two variables specified)

Misuse Code*	Factors Code**												
	1A1a	1A1b	1A2a	1A2b	1C	2C2a	4B	4C	5A	5B	6	7	Not Applicable
2A	X		X		X	X	X	X	X	X	X		
2D		X		X			X	X		X			
3A	X			X	X		X	X					
4	X	X			X	X	X	X			X		
6A	X	X	X	X	X		X	X	X	X			
6B,C	X			X	X		X	X	X	X			
7	X				X		X	X		X			
9A,B,D,G,H	X				X	X	X	X	X		X		
9C	X	X	X	X	X	X	X	X		X	X	X	
9E	X		X			X	X	X			X		
10B					X	X	X	X	X			X	
None												X	X

*As specified in Exhibit 2.
**As specified in Exhibit 7 or Exhibit 22.

Exhibit 33: Cross-Tabulation of Variables Applicator/Application Type and Factors Leading the Pesticide Misuse (X's designate the most significant combinations of the two variables specified)

Applicator/ Application Type Code*	Factors Code**												
	1A1a	1A1b	1A2a	1A2b	1C	2C2a	4B	4C	5A	5B	6	7	Not Applicable
1A,1B	X				X		X	X	X	X		X	
1E	X				X		X						
1F	X		X		X	X	X	X	X	X	X	X	
4D, 4E							X	X					
4F		X			X		X	X		X		X	
5E					X			X	X				
6G		X			X		X	X		X		X	X
7G								X			X		X
8D, 8E		X			X		X	X					
8F		X		X	X	X	X	X		X		X	X
9G		X								X			X

*As specified in Exhibit 4.
**As specified in Exhibit 7 or Exhibit 22.

Exhibit 34: Cross-Tabulation of Variables Pesticide and Pesticide Misuse (X's designate the most significant combinations of the two variables specified)

Pesticide	Misuse Code**												
	2A	2B,C,E,F	2D	3A	4	6A	6B,C	7	9A,B,D,G,H	9C	9E	10B	None
Bird Poisons and Repellents				X	X		X			X			X
Fungicides	X				X	X		X	X	X		X	
Herbicides	X				X	X		X		X	X	X	X
Insecticides	X	X	X	X	X	X	X	X	X	X	X	X	X
Rodentidicde			X	X		X				X			
Other Pesticides*		X	X	X	X		X			X			

*Other pesticides include anticicrobial agents, fish poisons, and repellents, invertebrate animal poisons and repellents, mammal poisons and repellents, plant regulators, and slimicides.
**As specified in Exhibit 2.

Exhibit 35: Cross-Tabulation of Variables Applicator/Application Type and Pesticide Misuse
(X's designate the most significant combinations of the two variables specified)

Applicator/ Application Type Code*	Misuse Code**														
	2A	2B,C,E,F	2D	3A	4	6A	6B,C	7	8	9A,B,D,G,H	9C	9E	10A	10B	None
1A,1B	X				X	X		X		X	X	X	X		
1E			X												
1F	X			X	X	X	X	X	X	X	X	X		X	X
4D,4E	X											X	X		
4F	X			X	X	X	X								
5E										X				X	
6G		X									X				X
7G										X	X	X			X
8D,8E		X	X		X		X		X	X				X	
8F			X	X	X	X	X	X	X		X		X		X
9G					X	X									X

*As specified in Exhibit 4.
**As specified in Exhibit 2.

Exhibit 36: Cross-Tabulation of Variables Method of Use and Pesticide Misuse
(X's designate the most significant combinations of the two variables specified)

Method of Use Code*	Misuse Code**													
	1	2A	2B,C,E,F	2D	3A	4	6A	6B,C	7	9A,B,E,G,H	9C	9E	10B	None
1										X				
2									X					
4A		X			X	X	X	X		X	X	X	X	
4B1a		X		X	X	X			X	X	X	X		X
4B1b		X	X	X	X	X	X		X		X			
4B2,4,5,7,8, 9,11,12,13	X		X	X	X	X	X	X	X	X	X		X	
4B3	X			X	X	X					X			
4B10				X		X	X				X		X	
6													X	
7								X						

*As specified in Exhibit 5.
**As specified in Exhibit 2.

and other pertinent characteristics associated with different pesticide misuses (i.e., the pesticide involved - Exhibit 34, the applicator/application type involved - Exhibit 35 and, the method of use involved - Exhibit 36).

Comments on the Taxonomy of Consumer Safety Officers

In order to obtain some feedback about the taxonomy, interviews were conducted with EPA Region IV Consumer Safety Officers. The PMRC misuse cases investigated by these CSO's were used as a basis for discussing the taxonomy.

The initial responses of investigators to the factors taxonomy were strongly influenced by their own philosophies of misuse behavior, which were often simplified to one or two sentences. A commonly stated reaction was that the factors were analytically useless because all misuse was a result of "ignorance". Alternatively, another investigator attributed "most" misuse to "stupidity" or to "stupid actions". A more sophisticated first statement involved a two-factor theory of misuse- e.g., "ignorance" and "willful disregard of label". These theories probably reflected the investigators' difficulty in coping philosophically with occurrences of very complex, and sometimes bizarre, behavior in contexts where they had not time and no directive to analyze underlying factors.*

Nevertheless, the CSO's were capable of discussing the various factors as possible contributing items in misuse occurrences. The method of open-ended discussion of factors (with a few specific PMRC misuse case records to discuss for reference) led to a "final" designation by the CSO of one or two major factors. Indeed, certain factors were consistently indicated by the CSO's as explaining why the majority of misuse cases took place, e.g., economic incentives, training of the user-basic educational qualities, ignorance, carelessness or negligence and, intervening social conditions-habit and local custom. Like wise, certain factors were not mentioned by the CSO's, e.g., institutional constraints, physical ability of user, intervening natural conditions and product label deficiencies. (Note that CONSAD's review of the PMRC cases did indicate these factors as contributing to misuse - see Exhibit 25).

Thus, investigators adopted the "factors" approach or philosophy, but only after a 10 or 15 minute discussion. It is likely that similar adoption could be obtainined by a page or less of instructions, but it is not safe to conclude that the factors taxonomy could be distributed for use without any personal contact for answering questions and for making sure the instructions were carefully read. Moreover, the CSO's noted that if someone, other than themselves, were to assign various factors to a misuse case based on reading their investigation report, that the factors chosen would probably be different than the ones they would have chosen. Consequently, the reliability of obtaining the same responses from different people must be questioned. Perhaps the CSO who investigated the misuse case would have to be the one to obtain the information and code the factors. This does not mean that the information would

*All CSO's pointed out that determining why a misuse occurred was not part of their function nor were they to inject personal opinion or conjectures into their reports. Most, however, felt that they could indicated, with some certainty, those factors contributing to a misuse case that they investigated.

have to go into the CSO's investigation report, but rather, it could be recorded separately for analysis purposes by others in OPP and PTSED.

In conclusion, it is discouraging to note the current lack of an analytical approach to the motivational factors which influence misuse, particularly in light of the attitude/motivation emphasis which has emerged in industrial psychology. Furthermore, the ready ability of the investigators to relate the taxonomy structure to their own experience suggests that they would find such a structure useful in their day-to-day investigations.

PESTICIDE USE PROCESS ANALYSIS

Introduction

As indicated in previous sections, using pesticides in a safe and proper manner involves a complex set of activities and behavior. To enhance one's understanding about the nature of pesticide use and misuse for a given pesticide/applicator/use situation (PAU), or for a group of similar PAU's, flow charting the work elements involved can be a useful approach. Utilizing this technique, a detailed analysis of the pesticide/applicator/use situation would be undertaken and the result would be a step-by-step procedure outlining all of the various tasks and behaviors involved for a certain PAU or for a group of similar PAU's.

Once this were accomplished, then the investigator could use actual data on pesticide misuses and indicate the types of misuses associated with each of the steps in the work flow chart. Moreover, the types of effects that are likely to result and the factors that are important for explaining why the particular type of misuse occurred could be ascertained. Developing such data would empirically define the critical points of the pesticide use process and they could be used to refine the Taxonomy of Factors Leading to Pesticide Misuse, as well as to develop compliance strategies that would minimize misuse and the resultant environmental damage in as cost-effective way as possible.

This type of work process analysis has been done in other industries* with success. Its applicability to the pesticide industry (and specifically the use of pesticides by various kinds of applicators) however, could be more difficult due to the vast variety of pesticide/applicator/use situations and the variations that exist amongst the types of applicators.

Nevertheless, this type of analysis should be considered. Possibly it could be more formally introduced into large scale use observations, such as those performed by the EPA's National Enforcement Investigations Center (NEIC) under contract to PTSED. If successful, then further study could be done to attempt to group similar PAU's so that the number of pesticide use process analyses could be kept to a reasonable size.

*For example, see Theodore Barry and Associates, Inc., Behavioral Analysis of Workers and Job Hazards in the Roofing Industry, NIOSH Research Report, Cincinnati, Ohio, June, 1975.

Illustrative Example

The pesticide use process chosen for illustration is the aerial application of pesticides purchased by agricultural land owners for use on agricultural crops. The rationale for this selection was generated from the review of PMRC misuse cases; that is, approximately one fourth of the cases reviewed by the PMRC involved pest control on agricultural crops by "for hire" aerial applicators.

Exhibit 37 presents a hypothetical work flow chart for this pesticide use process. The circled numbers on the flow chart correspond to the task numbers that appear in Exhibit 39 which describes the types of misuse that could result, the factors that could have led to the misuse and the health or environmental effects that could have resulted from the misuse. Although Exhibit 39 was partially generated from data extracted from the PMRC misuse cases, the reader is cautioned that this presentation is primarily for illustrative purposes only. Further data gathering and analysis, beyond that of reviewing the limited number of misuse cases available through the PMRC, would be necessary.

Nevertheless, some comments are worthy of note. For example, reviewing Exhibit 39 and frequency data from the PMRC misuse cases, indicates that the agricultural pesticide application process by aerial applicators can result in many types of misuses. Most notable are misuses involving failure to follow label restrictions or limitations in order to protect human health or the environment (type 9), followed by improper application site (type 2A). Other types of misuses include improper dosage rate (type 4), improper application equipment (type 6) and improper clothing (type 7). Seldom noted misuses include improper applicator certification (type 1), improper frequency of applications (type 5) and improper re-entry intervals (type 8).

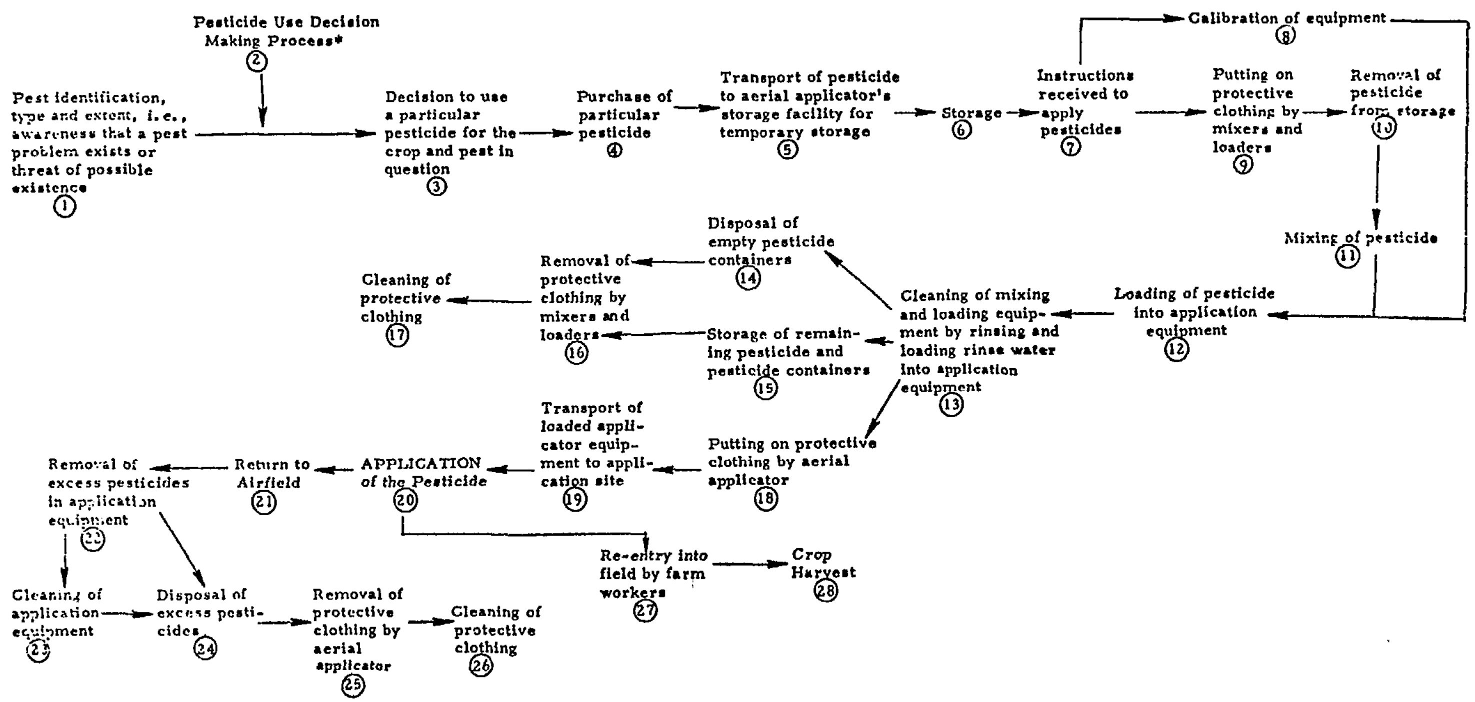
In terms of factors leading to the misuse, economic motives (type 1A) and the training of the user (type 4) were most common in the PMRC misuse cases for aerial applicators of agricultural pesticides. Willfull disregard for the environment or human health (type 2C2a), intervening social conditions (type 5) and intervening natural conditions (type 6) were also important factors.

The most common health or environmental damages were effects to soils, crops, plant life (type 5), followed by occupational exposure (type 1), wildlife effects (type 4), no effect, non-occupational exposure (type 2), domestic animal exposure (type 3), and contamination to structures (type 6).

Concluding Remarks

The above illustrative example has shown how the flow charting of the pesticide use process can be used in conjunction with data on pesticide misuses to indicate those task operations most critical in terms of particular types of misuse, factors leading to misuse and/or resultant health or environmental effects. As additional misuse data is collected and the data base augmented, more sophisticated statistical analyses would be possible to further pinpoint critical steps in the pesticide use process. These in turn could be used as input into designing compliance strategies.

Exhibit 37: Work Flow Chart for Aerial Application of Pesticides Purchased by Agricultural Land Owners (Hypothetical)



*See Exhibit 38.

Exhibit 38: Forces Influential in the Pesticide Use Decision-Making Process by Agricultural Crop Producers*

1. Personal Resources

   a. past practices to pest control (i.e., tradition)
   b. financial resources
   c. information seeking activities
   d. managerial skills (i.e., sophistication)
   e. pesticide dealer contacts and ties

2. Institutional Network

   a. extension service
   b. agricultural experiment station
   c. pesticide dealerships
   d. chemical companies
   e. lending institutions
   f. professional scouting
   g. professional application
   h. Federal crop insurance
   i. mass media
   j. neighbors, friends, relatives

3. Noncontrollable Factors

   a. inflation
   b. weather
   c. fluctuating market conditions
   d. pest infestations
   e. pesticide shortages

*CONSAD Research Corporation, Short Term Agricultural User Adjustment Problems Associated with Major Pesticide Regulatory Restrictions, EPA Contract Number 68-01-1917, November 30, 1976.

Exhibit 39: Analysis of the Work Flow Chart Tasks

Task Number	Typical Types of Misuse That Could Result*	Factors That Could Have Led to the Misuse**	Health or Environmental Effects That Could Have Resulted from the Misuse***
1	Not Applicable	Not Applicable	Not Applicable
2	Not Applicable	Not Applicable	Not Applicable
3	2A, 3A	1A1a, 4C, 4, 1A2a, 1C, 7.	None
4	1, 2A, 3A	1A1a, 4C, 5, 1A2a, 1C, 7	None
5	9D, 9F	1A1a, 4C,	1, 5, 6
6	10A	1A2a, 4C	2, 4, 5, 6
7	3B, 5	1A1a, 6E	None
8	4A, 4B, 4C	1A2a, 4C	None
9	7A, 7B	4B, 4C, 1C, 6C, 5	None, 1
10	9D	4B, 4C	1, 4, 5
11	4, 9D, 9F, 9G	4B, 4C, 5	1, 4, 5, 6F
12	9D, 9F, 9G	4B, 4C	1, 4, 5, 6F
13	9D, 9F, 9G, 10B	4B, 4C, 5	1, 4, 5, 6F
14	10B	1A2a, 4B, 4C, 5	1, 4, 5
15	10A	1A2a, 4B, 4C	2, 3, 5, 6
16	7A	4B, 4C, 6C	None, 1
17	7B3	1A2a, 5	None, 1
18	7A, 7B	4C, 6C	None, 1
19	9C, 9D, 9E, 9F, 9G	4C, 6F	2, 3, 4, 5, 6
20	1, 4, 6A1, 9C, 9E, 9J	1A2a, 2C2a, 4C, 6	2, 3, 4, 5, 6A, 6F
21	9C, 9D, 9E, 9F, 9G	4C, 6F	2, 3, 4, 5, 6
22	10B	4C, 5	1, 4, 5
23	10B	4C, 5	1, 4, 5
24	10B	4C, 5	1, 4, 5
25	7A	4C, 6C	None, 1
26	7B3	1A2a, 5	None, 1
27	8A	1A1a, 5	None, 1
28	9A	1A1a, 6C	1, 3, 5B

*As specified in Exhibit 2
**As specified in Exhibit 7 or Exhibit 22.
***As specified in Exhibit 6.

CHAPTER 6

COMPLIANCE STRATEGIES FOR REDUCING PESTICIDE MISUSE

CRITERIA FOR DESIGNING COMPLIANCE STRATEGIES

In Chapter 5, the various antecedents to pesticide misuse were explored. Not surprisingly, it was found that complex behavior is required by the pesticide applicator and that the avoidance of misuse requires that this behavior be produced carefully, accurately and repeatedly. In other words, when pesticide misuse does occur, both human behavior and human error are involved, as was indicated in the Taxonomy of Factors Leading to Pesticide Misuse (i.e., Exhibit 22).

Therefore, in order to reduce pesticide misuse and any associated resultant environmental damages, strategies must be designed to obtain the most careful and accurate behavior from pesticide applicators. Consequently, behavioral change on the part of the pesticide user is required and various mechanisms, compliance strategies, i.e., can be used to effect this change in behavior.

However, compliance strategies must also be connected to particular types of misuse because the purpose of the present project is to analyze misuse types, and to devise cost-effective compliance strategies. In other words, compliance strategies must be designed specifically for particular kinds of pesticide/applicator/use situations (PAU's), particular types of misuses that result, and the associated factors leading to the misuse, so that they can be selected to meet an exact problem, and so that the results of a compliance strategy can be precisely evaluated.

In addition to these basic requirements, the set of compliance strategies to reduce all types of misuse must also be designed to meet the following criteria:

- They must be cost-effective in reducing misuse, e.g., the cost of the strategy must not exceed the dollar value of the damages saved from reduced misuse and moreover, the ratio of strategy cost to damages saved should be as small as possible;

- They should provide for desirable changes in pesticide labels;

- They should be able to change the behavior of all relevant parties involved in the pesticide use/ misuse process, if necessary (this includes, in addition to the actual user, pesticide dealers, equipment suppliers, professional pest control advisors, extension service personnel, etc.);

- They should be cognizant of the institutional service network, and of their various capabilities for effecting behavioral change amongst users of pesticides, i.e., compliance strategies should indicate how various institutions would be involved in influencing people to use pesticides properly;

- Any particular strategy should be applicable to the same general type of misuse (and underlying factor(s) leading to the misuse) and to the same pesticide use situations; e.g., a strategy for reducing spray drift of pesticides from field crops which is caused in large part by carelessness or negligence, should be approximately useful for any such problem, independent of region, state, time of year or other extraneous conditions;

- They should incorporate pre-defined measures of effectiveness for subsequent evaluation;

- They should be based on an accumulated file of successes and failures of similar type strategies, either in laboratory or "real world" settings, if possible;

- They should be efficient, by addressing only the specific behavior and actions which directly lead to the misuse;

- They should try to distinguish between those strategies directed at factors leading to misuse that the user has no control over, from those strategies directed at factors leading to misuse that the user does have control over;

- They should not be based on intimidation, invasion of privacy, or other principles of dubious legality; and

- They should be consistent with the intent and legal requirements of FIFRA, as amended.

EVALUATING COMPLIANCE STRATEGIES

As indicated in the above criteria, there must be procedures and methods for comparing and evaluating alternative compliance strategies, not only at the time they are selected for implementation, but also at various stages after they are in use. It is possible to imagine and design a great range and variety of compliance strategies and techniques, some of which, such as specialized training courses, might cost a great deal of money. Not only must a selection be made among strategies and programs for trial implementation, but impact calculations must also be made at various points after the program is in effect.

Exhibit 40 outlines various dimensions on which to evaluate a compliance strategy's effectiveness and applicability to the reduction of pesticide misuse. Some of these dimensions are conveniently assessed both prior to and after the implementation and operation of a strategy, but others would be more appropriately assessed only after the strategy has been in operation for some reasonable period of time. There is no simple absolute rule about when a variable should be estimated or measured. In fact, even long term changes, such as certain health and environmental damages that would be reduced, can be estimated from laboratory data before a compliance strategy is implemented. In other words, a thorough knowledge of the details of the processes and mechanisms which are impacted by pesticides, will enable the rough estimation of the expected effects of stopping misuse.

Nevertheless, some of the benefits from reduced misuse are highly probablistic, such as the reduced chance of exposure of farm workers, or the reduced chance of illness of industrial workers. In such cases, one approach is to implement a strategy -- such as inspection and education -- which will reduce the chance of adverse effects of misuse to a very low level. In these situations, where the danger of such effects must be minimized, then agency determination of the appropriate cost for a compliance strategy becomes most important.

Thus, the cost of implementing and operating the compliance strategy will be a "first test" or screening device to aid in the design and selection of "efficient" compliance strategies which operate smoothly and require simple organizational structures (efficiency of operation must not be confused with overall cost-effectiveness). Cost data should be estimated on the basis of personnel, travel, equipment, and administrative costs. For a training program, the equipment costs would include demonstration apparatus, mockups and behavior measurement instruments.

Although implementation and operating costs should be based on standard agency-wide costs, even these data will only be estimates of the actual (eventual) strategy cost. For example, the steady state program costs (i.e., operating costs) will not be known until the program has been operating for several months, or even a few years.

Furthermore, estimating compliance costs which might accrue to users, distributors and formulators will be even harder to estimate but are of utmost importance. Some of these costs will be "conversion" costs and will be transient only, assuming the compliance strategy is well designed. For example, a

Exhibit 40: Dimensions on Which to Evaluate a Compliance Strategy

- What factors leading to misuse will the compliance strategy reduce, i.e., what factors is the strategy designed to modify?

- Given the factors leading to misuse that the strategy is designed to modify, what types of misuse will the compliance strategy reduce?

- Is the strategy more appropriate (or only appropriate) for particular:

  - types of pesticides misused?
  - types of applicator organizations or personnel?
  - types of use procedures?
  - types of target sites?

- Does the strategy prevent a misuse from happening for the first time, from recurring, or both?

- What are the associated benefits (i.e., reduced health and environmental effects) for each type of misuse that is expected to be reduced by the compliance strategy?

- How effective is the strategy, i.e., how many misuses of a given type were prevented in a specified time period (subtract monitored level of misuse with strategy from forecasted level of misuse without strategy) and, how severe would these misuses have been, e.g., what is the dollar value of the damages saved from the reduction in misuse?

- What will the strategy cost to implement and operate:

  - <u>Implementation costs</u>, e.g., has the strategy been used before in achieving compliance with pesticide labels, what institutional and/or other arrangements are necessary for the strategy to be implemented, how suitable is the strategy given the institutional makeup in the geographic location that the strategy is to be utilized, etc.?

  - <u>Operational costs</u>, e.g., personnel, travel, equipment, administrative, etc.

- What will the compliance cost of the strategy be to the affected user, i.e., what is the cost of changed operating procedures and productivity in the farm or industrial/commercial setting as a result of complying with the given strategy?

- What is the relative cost-effectiveness of the strategy:

  - What is the ratio of strategy cost (implementation and operating costs) to the value of damages prevented from reduced misuses of a given type?

  - What is the ratio of compliance cost to the value of damages prevented from reduced misuse of a given type?

manufacturer may have to change his label, but after the change is made, the new label should cost no more to print than the old label did. In some cases, the compliance strategy may lead to a long term continuing or recurring compliance cost (e.g., monitoring or disposal equipment), either for users, distributors, or formulators. In such cases, the costs must be carefully weighed against the expected benefits from reduced misuse. Such burdensome compliance strategies must be viewed as having a low probability of successful implementation.

After calculating the various costs of a compliance strategy, the possible benefits should be estimated based on the best available data on accidents and dispersal, exposure and human and environmental injury.* If the PAU for a proposed compliance strategy if well known, then multi-year benefit calculations are certainly justified. These long-term (e.g., 10 year) benefit estimates are "futuristic" in the sense of being contingent on many unforeseeable influences, but for compliance strategy selection, they should be done as the only professionally thorough and acceptable type of analysis.

Once a strategy is selected and implemented, then an ongoing evaluation must be implemented immediately. Compliance strategies by definition inevitably have broad effects on individual human behavior, institutional structures, and technologic components of society. Such an action by a regulatory agency is bound to have some governmental, administrative, and political implications, and the regulatory agency is compelled to produce program evaluation information quickly.

These "immediate" evaluations should have a variety of decisions contingent upon their results, e.g., terminate the compliance strategy, expand its scope, narrow its scope, wait for more long-term evaluation results, etc. Whatever the results of the evaluation, the implementing agency must be prepared to continue its evaluation effort, and to modify and/or replace the compliance strategy as soon as such a need exists.

STRUCTURE OF COMPLIANCE STRATEGIES

Compliance strategies to effect change in the behavior of applicators when using pesticides can be of many varieties. For example, the strategy can attempt to change the user's behavior indirectly through: 1) institutional/organizational considerations, or 2) engineering psychology techniques (i.e., designing equipment and work operations to optimally match the capabilities and limitations of the worker population, with special emphasis on human performance requirements). Alternatively, the strategies can try to effect change in a more direct way, for example through: 3) training and education, or 4) behavior modification techniques (e.g., using reinforcing stimuli when a desired response is observed or using negative incentives when undesired behavior occurs). A combination of these four techniques is also a possibility.**

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*The PLAINS, described in Chapter 4, can be utilized here.

**For a brief review of the industrial safety literature, the reader is referred to Appendix C.

Exhibit 41 outlines various approaches to achieve compliance with pesticide labels. The first two approaches deal with the user's behavior indirectly and therefore, deal more with those factors leading to pesticide misuse that are beyond the control of the user. The latter two approaches deal with factors leading to misuse that can be controlled by the user, and hence, these approaches directly affect the user's behavior. The approaches are designed to be both comprehensive and somewhat overlapping, but most importantly, they should provide the necessary mechanisms to alleviate any and all types of behavior antecedent to pesticide misuse occurrences. The areas of overlap should provide a basis for interconnecting compliance strategies so that a given strategy can use a combination of two or more approaches, if desired.

Each of these approaches are discussed in the following sections.

Institutional/Organizational Considerations

Previous research in organizational development has indicated that if the institutional/organizational network promotes a climate that encourages safety, workers will be more likely to adopt safe practices.* Consequently, in order for pesticide applicators to properly use pesticides, the institutional/organizational climate should be one that not only fosters the importance of using pesticides correctly, but one that also is capable of correcting deficiencies in the institutional/organizational network. The "actors" in this institutional/organizational network would include state and Federal regulatory personnel, chemical company personnel, pesticide dealers and equipment suppliers, pest control firms, extension service personnel and professional pest control advisors. Therefore, institutional/organizational considerations constitute the first type of strategy for achieving compliance.

One type of institutional/organizational approach would include activities that monitor the use and misuse of pesticides (type 1A approaches in Exhibit 41). These activities would be carried out by regulatory personnel and have been previously described in detail in Chapter 4, Development of a Pesticide Label Adherence Information System. The basic notion here is that if users know that active monitoring of pesticide use and misuse is taking place, they will, hopefully "think twice" about misusing pesticides due to the fear of being caught via a tank sample analysis, establishment inspection, user audit, etc. In particular, if a certain user knows of a friend or relative who had his pesticide use practices scrutinized, this can be a strong deterrent for him from doing similar kinds of things. Thus, this is one approach to reduce the level of volitional misuse of pesticides.

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*Tuttle, T.C., H.P. Dachler and B. Schneider, "Organizational Psychology", in Margolis, B.L. and W.H. Kroes (editors), The Human Side of Accident Prevention, Springfield, Illinois: Charles C. Thomas, 1975, pp. 7-44.

Exhibit 41: Approaches to Achieve Compliance with Pesticide Labels

1. **Institutional/Organizational Considerations**

A. Actively monitor pesticide use and misuse
   1. Control use of pesticides
      a. issue purchase permits
      b. issue use permits
      c. require certification
      d. require notices of intent to apply pesticide
   2. Take tank samples from application equipment
   3. Inspection and licensing of equipment
   4. Establishment inspections for those who can be considered as distributors or sellers of pesticides
   5. Routine use inspections (use observations)
   6. Require accident reporting
   7. Misuse investigations soon after alleged misuse occur
   8. use audits

B. Change product labeling
   1. Make instructions, precautions, etc., more explicit to reduce potential for misuse
   2. Augment available uses to cover more pests, more sites, etc., e.g., promote the registration of local need pesticides, promote the registration of minor use pesticides

C. License dealers, professional pest control advisors, etc. and require recommendations in writing to the user

D. Require certified supervisors to be physically present during pesticide use operations with restricted use pesticides

E. Promote adequate pesticide supplies or equipment outlets

F. Promote the use of public pressure to bring about compliance
   1. public hearings
   2. press coverage

G. Promote the development of knowledgeable experts who users can consult when pest problems arise

H. Promote the development of "easy access" disposal sites for excess pesticides and/or containers

I. Promote self regulation by the pesticide application industry (i.e., get application industry to promote and "enforce" proper and safe use of pesticides amongst their employees and/or trade association members)

2. Engineering Psychology Techniques

A. Redesign equipment or protective clothing to make more compatible with the structural and functional characteristics and dimensions of pesticide users, as well as with the physical environment in which the equipment or clothing must be used.

B. Redesign equipment to prevent misuses from occurring, e.g., have closed mixing and loading systems to prevent spills; require instrumentation in airplanes to tell pilots of weather conditions; design application equipment so that calibration procedures are made easier, etc.

C. Restructure sequence of tasks so that related tasks are performed as part of the same job by the same person

3. Training/Education Techniques

A. Verbal warning that violation of law occurred

B. Consultation with pesticide users prior to use regarding safety and use procedures, as well as the "do's and don'ts" of the pesticide law

C. Formalized training programs for pesticide users
   1. applicator certification program administered by the states in cooperation with state extension services
   2. chemical company sponsored programs
   3. trade association sponsored programs (e.g., National Pest Control Association)

Exhibit 41: Approaches to Achieve Compliance with Pesticide Labels (Continued)

D. **Informal seminars about pesticide safety, use procedures and the pesticide law**
   1. extension service conferences for different user groups (e.g., farmers, PCO's, ornamental and turf people, etc.) with presentations by enforcement personnel - county, multi-county or state conferences
   2. commodity type training sessions for particular crop/pest situations
   3. trade association seminars sponsored in part by EPA

E. Pesticide use safety campaigns (including "scare tactic" safety campaigns that show resultant health or environmental damage from various kinds of pesticide misuse)
   1. pamphlets and brochures on pesticide safety and use procedures
   2. television commercials
   3. billboard signs
   4. signs in pesticide dealerships
   5. public school programs
   6. service organization programs (e.g., 4-H, Boy Scouts, Girl Scouts, YMCA, etc.)
   7. church sponsored programs (e.g., sermons preaching pesticide safety)
   8. public interest group programs
   9. "in house" programs sponsored by private pest control firms for their employees

4. Behavior Modification Techniques

A. Positive reinforcers
   1. economic/material incentives
      a. allow users to apply prospective fines and penalties towards correcting the misuse situation (in lieu of paying the fine to a regulatory agency) if appropriate (e.g., require users who do not have protective clothing to purchase necessary clothing in lieu of a fine)
      b. compensate users to attend training courses and seminars
      c. use of bonuses, pay raises, promotions, special priviledges, gifts, extra vacation, etc., when proper safety and use procedures are utilized.
      d. <u>minimize</u> the effort and discomfort of <u>safe practices</u> and <u>maximize</u> the effort and discomfort of <u>unsafe practices</u> (e.g., permanently provide well designed comfortable protective clothing for appropriate situations)
   2. normative incentives, i.e., stress the opportunity for the user to contribute to valued ideals such as environmental quality, precision job performance, community service, etc.

B. Negative reinforcers or punishers, i.e., legal enforcement remedies
   1. citations
      a. violation notice
      b. warning notice
      c. civil penalty warning citation
   2. informal meeting before Pesticide Board or equivalent body
   3. formal hearing before Pesticide Board or equivalent body
   4. penalties/fines/jail
      a. civil prosecution via district attorney's office (fine and/or jail)
   5. suspension or revocation of license or certification following an administrative (or disciplinary) hearing
   6. injunctive procedures
      a. stop sale order
      b. stop use order
      c. removal order
      d. seizure
      e. formal recalls
      f. import detentions
   7. rehabilitation programs

The remaining compliance strategies under institutional/organizational considerations primarily deal with those factors leading to pesticide misuse that are largely beyond the control of the pesticide user, e.g., institutional constraints as well as product label deficiencies. For example, to help insure that pesticide dealers' motives are consistent with the proper use of pesticides, dealer licensing (a type 1C strategy) can be used. Similarly, to insure that pesticide users receive proper use instructions, a strategy to augment the supply of knowledgeable experts (type 1G) would be beneficial.

Finally, of particular interest is the approach of having the pesticide application industry create an atmosphere that promotes the proper and safe use of pesticides amongst their employees and/or trade association members (a type 11 approach). For example, workers' attitudes can be geared towards safety and proper use procedures if the organization in which they work (or are associated with) promotes such ideas. Thus volitional and nonvolitional misuse can be controlled, as well as factors leading to misuse that are beyond the control of the user. However, for many pesticide users, notably those who are not employed by large pest control firms (e.g., farmers, small PCO firms, aerial applicators), the organizational framework for using this approach may not be readily discernable. Nevertheless, appropriate trade associations at the local, state, and national level can be used as mechanisms for implementing this strategy with these pesticide users.

Engineering Psychology Techniques

The basic premise behind engineering psychology techniques is that "workers can and do successfully adapt to a wide variety of tasks and situations, but it is an unrealistic organizational practice to require them to compensate for engineering design deficiencies in equipment and work operations without a corresponding increase in errors and accidents.* Therefore, the second type of approach to achieve compliance consists of those strategies designed to correct for equipment deficiencies or work operations which cause or contribute to pesticide misuse occurrences, and which are, to a large extent, beyond the immediate control of the user.

Three examples are given in Exhibit 41 (approaches 2A-2C) where engineering psychology techniques can be applied as compliance strategies to help insure pesticide label compliance. As is indicated, mixing and loading procedures, as well as the use of protective clothing, could be much improved through such principles.

However, these three approaches far from exhaust the application of such techniques in the pesticide use/application process. Indeed, further work by engineering psychologists, as well as individuals familiar with the pesticide use process is sorely needed.

For example, the tasks involved in the pesticide use/application process should be carefully reviewed (as was suggested in Chapter 5), paying particular attention to the sequence of tasks involved and the equipment utilized. Once

*Grether, C.B., "Engineering Psychology", in Margolis, B.L., and W.H. Kroes (editors) op. cit., p. 45.

this is accomplished, additional strategies can be devised based upon the application of engineering psychology techniques.

Training/Education Techniques

A third major type of compliance strategy deals with training and education techniques that would provide the pesticide user with the necessary skills, knowledge, concepts and attitudes to use pesticides in a safe manner and in accordance with label instructions. This third type of strategy overlaps both the institutional category as well as the engineering psychology category, but it also provides some specialized training technique approaches needed for a complete "tool-kit" of training approaches. This approach to achieving compliance with pesticide labels is not a new one and many organized program environments have and are being used to make pesticide users aware of the hazards of pesticides and the importance of reading and following label directions carefully. These program environments are described as the type 3 approaches in Exhibit 41.

As indicated in that exhibit, some program environments provide a far more formalized setting for training and education than others. For example, a verbal warning (i.e., type 3A approach) given to a pesticide user when a violation of the law has occurred is a somewhat informal program environment in that this approach is used when an inspector visits a pesticide user and requests that a minor infraction be corrected. Although a written inspection report is also completed, this warning is viewed as more of an educational courtesy than a warning, since the pesticide user is being informed (i.e., educated) about the pesticide law and how the pesticide should be used. This approach can be an effective one if the pesticide user community respects the inspector giving the verbal warning.* Another informal approach that has been found to be effective has been consultations with pesticide users (a type 3B approach) when restricted material permits are issued to apprise the users about the pesticide law, the importance of using pesticides according to label instructions, and any specific precautions concerning the restricted material permit issued.**

In contrast, the applicator certification program (type 3C1 approach) now underway in the states in varying degrees, is a far more formalized training and education approach and in many instances, requires that users attend classes and pass written examinations. Training materials have been prepared by the USDA, the EPA and the various states.*** Moreover, EPA has passed regu-

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*California Department of Food and Agriculture, Division of Inspection Services, 1975 Pesticide Use Enforcement Grant - Final Report, January, 1976, pp. 55, 71-72.

**Ibid.

***For example, see USDA, Extension Service and EPA, OPP, Apply Pesticides Correctly - A Guide for Commercial Applicators, 1975; and EPA, OPP, Apply Pesticides Correctly - A Programmed Instruction Program for Private Applicators, Revised, March, 1976.

lations that set standards that state plans must meet in order for states to certify pesticide applicators.* The impact that such programs will have on label adherence is difficult to judge given the variety of the state programs and the various stages of implementation that exist amongst state programs.**

Somewhat less formalized training and education approaches (type 3D approaches) include seminars sponsored by the extension service and various trade associations on topics such as the use of particular types of pesticides or the control of particular pest problems. Another less formalized training/education approach is pesticide use safety campaigns (type 3E approach). These campaigns can be sponsored by EPA, trade associations, or others. Although these programs can reach large numbers of pesticide users, there is one major drawback to safety campaigns. If the threat of the consequences indicated by the safety campaigns do not occur with the stated unsafe or pesticide misuse behavior, then the campaigns will lose their credibility and effectiveness; that is, the threats of undesirable consequences that are not fulfilled, could reinforce, rather than diminish pesticide misuse behavior.***

Finally, education and training programs, regardless of the mechanism utilized, cannot be effective alone to bring about compliance with pesticide label requirements, i.e.:

> "One of the reasons many training programs have been ineffective may be that the programs were designed to compensate for other organizational problems completely unrelated to employee knowledge or skills. Training cannot be viewed as an organizational panacea. The following examples illustrate problems essentially unrelated to training:
>
> 1. Tasks which have been designed without regard to human factors;
> 2. Situations in which the socio-psychological environment has not been accounted for; and
> 3. Situations in which job satisfaction and worker motivation have been ignored.
>
> A systems approach, involving a broader analysis of organizational problems and objectives, would indicate that training was inappropriate for dealing with these problems.
>
> Even in situations where training is potentially useful for the achievement of individual organizational objectives, success cannot be guaranteed. Any particular training program must be considered a research program in which the training system remains to be evaluated. Evaluation and redesign of training content, materials

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*See Code of Federal Regulations, Title 40, Chapter 1, Part 171.

**See "Status of State Certification Plans", report which is periodically prepared by EPA, OPP, Operations Division.

***See the discussion on behavior modification techniques below.

and methods to achieve specific training objectives and criteria provide the foundation for a systems approach to training."*

In essence, although education and training can be an effective tool for achieving compliance with pesticide labels, other techniques must also be used, e.g., organizational psychology, engineering psychology and behavior modification.

Behavior Modification Techniques

The last group of techniques available for effecting adherence with pesticide label requirements are those utilizing behavior modification principles. The foundation of behavior modification is based upon the principle "that people will act by a set of rules (even safety rules) if they are "paid" (reinforced) in a direct, immediate and consistent manner".** Consequently, behavior modification techniques are perhaps most applicable when misuses are volitional in nature.

The reinforcers used in behavior modification can be both positive and negative. Quite naturally, positive reinforcers tend to increase the likelihood of a specific behavior, whereas negative reinforcers tend to reduce the likelihood of the same type of future behavior. More specifically related to the pesticide use context, the last part of Exhibit 41 describes various reinforcers (type 4A approaches) and punishers (type 4B approaches) that have and/ or could be utilized by either regulatory agencies or private companies or both.

With respect to positive reinforcers, the definition and use of simple or traditional reinforcers is more complicated for programs in which public agencies (e.g., EPA) are involved than when private firms apply the incentives. The reason is partly that payments made by government agencies probably do not carry the same incentive value or weight as those made by a private firm to its employees. In addition, the administrative structure for incentives is not readily available in public agencies, and typically requires a contract or a legally constituted tax deduction or rebate. If incentive plans are devised in such a way that business deductions are advantageous, then the EPA would presumably have a much better chance of persuading farm employers and pest control firms to adopt them, but in such cases, the compliance strategy would require pre-development so that the financial advantages would be clear and compelling for the employer.

Thus, the use of monetary or "worker-benefit" incentives in designing compliance strategies is complicated by:

- The non-typical work context, which does not match assembly line or heavy industry situations; and

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*Goldstein, I.L., "Training", in Margolis, B.L. and W.H. Kroes, (editors) op. cit., p. 94.

**McIntire, R.W., and J. White, "Behavior Modification", in Margolis, B.L. and W.H. Kroes, (editors), op. cit., p. 114.

- The involvement of public agencies (Federal and state) which are required to apply misuse regulations and laws, and which have not traditionally used the above types of incentives.

Therefore, in designing and developing the positive reinforcing types of compliance strategies, the complexity of the pesticide application context demands that the use of positive reinforcers be carefully reviewed and a number of questions be answered, e.g.:

- How influential are pay, incentives, and promotions? What are their limits and what role can regulatory agencies play in this area?

- Are safety awards valued by anyone other than company safety officials or regulatory personnel?

- How reinforcing is praise from a company official as compared to an EPA or state pesticide inspector?

- Where do the values of labor, management, and regulatory personnel really coincide and really conflict?

Once these questions are answered, the direct and indirect roles that regulatory agencies play will be better understood.

With respect to punishment, various legal enforcement remedies are available under state* and/or Federal statutes and regulations. Sections 9, 13 and 14 of FIFRA, as amended, provide the legal basis for the Federal EPA to enforce Section 12(a)(2)(G). These legal approaches consist of citations, civil penalties, criminal prosecution and injunctive procedures (e.g., stop sale, use, removal or seizure orders). In addition, most states have the power to suspend or revoke an applicator's license or certification in order to achieve compliance with the pesticide law. In fact, the PTSED enforcement grant program in California noted that the county agricultural commissioners feel administrative action on a pest control operators license or certification is sometimes more effective than criminal action through the District Attorney's office because going through the District Attorney's office "often takes too much time and some cases concerning agricultural violations are not given the needed attention due to the lack of agricultural expertise by the District Attorney's personnel".**

In order to ensure that these legal enforcement remedies are uniformly applied, documents such as the one adopted by the California Agricultural Commissioners Association can be utilized.*** This document delineates what level

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*See EPA, OPP, Operations Division, Digest of State Pesticide Use and Application Laws, June, 1976, for a compilation of legal remedies on a state by state basis.

**California Department of Food and Agriculture, Division of Inspection Services, op. cit., pp. 72-73

***See "Suggested Enforcement Guidelines for Counties", in Appendix D.

of legal enforcement action is suggested for specific violations with consideration as to whether it is the first offense, second offense, etc. The applicable laws and regulations are also listed in a logical order to aid the inspector in citing the appropriate law or regulations sections violated. Moreover, EPA has prepared a document titled "Guidelines for the Assessment of Civil Penalties Under Section 14(a) of the FIFRA, As Amended",* in order to insure, to the extent practicable, that generally comparable penalties will be assessed in different regions for similar violations by EPA personnel.

McIntire and White stress that whenever possible, positive reinforcers are preferable to negative reinforcers. Positive reinforcers indicate to the individual being rewarded that his behavior was an acceptable one. Negative reinforcers (i.e., legal action) often times carry little information concerning the safe and proper procedures that should have been utilized. In addition, negative reinforcers tend to affect behaviors other than those to be suppressed since they have more general effects on behavior than positive reinforcers.

Nevertheless, from an organizational point of view, legal remedies may be easier to administer and it may not require as planned and complex a program as is often the case with rewards. Moreover, legal remedies may be the best way to modify behavior, particularly when there is no acceptable behavior to reinforce and particularly when pesticide misuses are volitional. However, whenever punishment is utilized, McIntre and White suggest that it be accompanied or followed by the use of reinforcement (e.g., if a pesticide user is reprimanded for not wearing protective clothing, once he begins to wear the clothing he should be praised in order to maintain the acceptable behavior).

In sum, the basic idea is to seek compatibility between the user incentive orientation and those which the use setting offers. Once this is achieved, the behavior modification techniques will be most effective.

Summary

In summary, four basic types of strategies have been suggested to achieve compliance with pesticide laws. Those strategies that deal with the institutional/organizational environment should be considered first by the misuse researcher and compliance strategist. That is, the first step towards creating an environment that promotes the proper use of pesticides, is to have an effective institutional/organizational network interested in ensuring that pesticides are used according to label directions, and moreover, that those label directions are sufficiently clear, and are neither overly restictive not too permissive. The second step towards assuring that pesticides are used in a proper and safe manner should be to use engineering psychology techniques and look at all of the machinery and equipment involved in pesticide use and application and make sure their design is compatible to the abilities of the human being required to use such machinery and equipment. Thirdly, pesticide users should be adequately trained and educated so that they know how to use pesticides in a safe way and in accordance with label directions. Finally, in order to main-

*See Appendix to the Code of Federal Regulations, Title 40, Chapter 1, Part 168.

tain safe and proper use practices amongst pesticide users, behavior modification techniques should be used to reinforce those principles associated with using pesticides according to label instructions.

DESIGNING SPECIFIC COMPLIANCE STRATEGIES

In reviewing the previous section, the reader undoubtedly noted that many of the compliance strategies presented in Exhibit 41 and then discussed in subsequent subsections, consisted of broad general approaches that were _not_ designed for given pesticide misuse types, their associated pesticide/applicator/use situations (PAU's) and those factors that led to the pesticide misuse occurrences. As required by the criteria for designing compliance strategies, specific strategies _can_ be designed from any of the categories or subcategories presented in Exhibit 41 _once_ the type of misuse (and method of use associated with the misuse), the PAU and the factors leading to the misuse are delineated.

However, it is _not_ realistic, in the current study, to delineate _specific_ compliance strategies for _specific_ misuse types and PAU's. Even assuming that it would be possible to select specific misuse types and PAU's to focus such an effort, designing specific strategies would still be difficult, until a sufficient profile of the misuse type and PAU were generated, i.e.:

- Type of misuse committed;
- Pesticide/applicator/use situation including:
  - Applicator team characteristics: number of people, relative training and experience as a team, and relative salaries;
  - Individual applicator characteristics: demographic, motivation, training and experience, and physical/mental condition;
  - Man-machine characteristics: operations required, tools needed;
  - Working conditions;
  - Probabilities of errors, machine failures;
  - Levels of danger;
- Method of use involved;
- Health and environmental effects; and
- Factors leading to the misuse.

Even then, selection of specific strategies would require great care _and_ a review of past successes and failures, if any, of utilizing the strategy for the given situation.

Nevertheless, a methodology for designing specific strategies can be suggested, leaving the implementation of such a methodology to regulatory personnel (or to subsequent research). This methodology would build upon the general approaches outlined in Exhibit 41 and would consist of the following steps:

Step 1: Determine those pesticide misuse types that should be reduced (the resultant environmental damage could be used as a means to prioritize misuse types).

For each pesticide misuse type identified in Step 1, proceed through Steps 2 through 5:

Step 2: Determine those factors leading to the pesticide misuse type.

Step 3: Determine those compliance strategies from Exhibit 41 that may be promising in modifying those factors leading to the pesticide misuse type.

Step 4: Select tentative strategies from Exhibit 41 for reducing the misuse type by utilizing the results of Step 3 and by assessing these additional factors:

- the pesticide/applicator/use situations involved;
- the method of use involved; and
- the resultant effects generated (i.e., how severe are they?).

Step 5: Further develop and specify these tentative strategies for the misuse and PAU's in question by using the data gathered in Step 4.

After each pesticide misuse type proceeds through Steps 2, 3, 4, and 5, perform Steps 6 and 7:

Step 6: Review the compliance strategy criteria and insure that the specific strategies generated by Step 5 above for each misuse type adhere to these criteria (i.e., modify the specific strategies as is necessary).

Step 7: After the specific strategies have been in operation for a specific time (e.g., six months or one year), evaluate each one utilizing the dimensions contained in Exhibit 40 and then proceed through the seven step procedure again.

The ranking procedure described in Chapter 3 could be used in performing Step 1 above. Then Exhibit 32* could be used in Step 2 to obtain insights into those factors leading to particular pesticide misuse types.

To perform Step 3, a two dimensional matrix, with factors leading to pesticide misuse as one variable and general approaches to achieve compliance as the second variable, could first be devised (see Exhibit 42). Those approaches that may be most appropriate for alleviating those factors leading to pesticide misuse are so indicated by an "X" in the appropriate cells. In developing this exhibit the assumption is made that those factors leading to misuse that are volitional in nature (e.g., economic incentives, pride, user constraints, willful disregard for label instruction, carelessness and negligence, local customs and habit), are best handled by behavior modification techniques and active monitoring of pesticide use and misuse. For those factors leading to misuse that are primarily a function of low levels of awareness, the assumption is made that they are best dealt with by training and education strategies as well as controls on who can use particular pesticides. In addition, for those factors that are largely beyond the control of the actual user (e.g., intervening natural conditions), the assumption is made that institutional/organizational considerations, as well as some training and education techniques, would be most appropriate. Furthermore, for those factors that are a function of the physical well being of the user (e.g., illness and fatigue), engineering psychology techniques are assumed to be appropriate. Finally, for those factors that are a function of the user's physical ability or mental well being (i.e., mental illness), the assumption is made that self regulation by the pesticide application industry, as well as strategies that control who can use pesticides, can best cope with these factors.

The reader is cautioned that these assumptions are not based on any empirical data base. Thus, the purpose of Exhibit 42 is primarily illustrative. Nevertheless, if Exhibit 42 was coupled with Exhibit 32, insights could be obtained concerning those general compliance strategies that could be used to alleviate certain types of misuse by using the factors leading to the misuse as the common link between these two exhibits. These results, plus additional information gleaned from the PMRC case reviews (e.g., see Exhibits 31, 33, 34, 35 and 36), could then be used in Step 4 to select tentative strategies from Exhibit 41. Steps 5 and 6 would rely on information generated in the previous steps and on information contained in this chapter. Once Step 7 was completed, this information could then be fed back into the seven step process and would be particularly useful for Steps 2, 3, and 4.

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*The reader will recall that Exhibit 32 contains a cross-tabulation of pesticide misuse types and factors leading to pesticide misuse with the most significant combinations designated by an “X” in the appropriate cells.

Exhibit 42: Cross Tabulations of Factors Leading to Misuse and Approaches to Achieve Compliance (X's designate those particular compliance strategies applicable to particular factors leading to misuse)*

Factors Leading to Misuse** \ Approaches to Achieve Compliance***		Type 1																
		1A1	1A2	1A3	1A4	1A5	1A6	1A7	1A8	1B1	1B2	1C	1D	1E	1F	1G	1H	1I
Type 1	1A1	X	X	X		X	X	X	X									X
	1A2	X	X	X	X	X	X	X	X									X
	1B	X	X	X	X	X	X	X	X									X
	1C1										X							
	1C2													X				
	1C3													X				
	1C4												X			X		
	1C5																X	
	1C6				X							X						
	1D			X	X	X	X	X										X
Type 2	2A																	X
	2B																	X
	2C1	X																X
	2C2a	X	X	X	X	X	X	X	X						X			X
	2C2b	X																X
Type 3	3	X																X
Type 4	4A	X											X					X
	4B	X								X			X			X		X
	4C	X	X	X	X	X	X	X	X	X					X			X
Type 5	5	X	X	X	X	X	X	X	X	X					X			X
Type 6	6	X		X			X	X	X							X		X
Type 7	7	X								X								

*For illustrative purposes only (empirical data would be necessary to verify the relationships that ths matrix purports to illustrate).
**As specified in Exhibit 7 or Exhibit 22.
***As specified in Exhibit 41.

Exhibit 42: Cross Tabulations of Factors Leading to Misuse and Approaches to Achieve Compliance (X's designate those particular compliance strategies applicable to particular factors leading to misuse)* (Continued)

Factors Leading to Misuse** \ Approaches to Achieve Compliance***		Type 2			Type 3					Type 4											
		2A	2B	2C	3A	3B	3C	3D	3E	4A1a	4A1b	4A1c	4A1d	4A2	4B1	4B2	4B3	4B4	4B5	4B6	4B7
Type 1	1A1				X										X	X	X	X	X	X	
	1A2														X	X	X	X	X	X	
	1B				X	X	X	X	X			X	X	X	X	X	X	X	X	X	
	1C1																				
	1C2																				
	1C3																				
	1C4																				
	1C5																				
	1C6																				
	1D									X		X	X	X							
Type 2	2A	X	X	X		X	X	X	X		X										
	2B	X	X	X		X	X	X	X		X										
	2C1																				
	2C2a								X					X	X	X	X	X	X	X	X
	2C2b																				X
Type 3	3																				
Type 4	4A		X	X	X	X	X	X	X			X									
	4B		X	X	X	X	X	X	X		X		X		X	X					
	4C				X	X	X	X	X			X	X	X	X	X	X	X	X	X	
Type 5	5				X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	
Type 6	6	X	X		X	X	X	X	X												
Type 7	7				X	X	X	X	X												

*For illustrative purposes only (empirical data would be necessary to verify the relationships that ths matrix purports to illustrate).
**As specified in Exhibit 7 or Exhibit 22.
***As specified in Exhibit 41.

APPENDIX A

STATE FEDERAL FIFRA IMPLEMENTATION ADVISORY COMMITTEE (SFFIAC) STATE ENFORCEMENT MATRIX*

*Developed and circulated by the SFFIAC Working Group on Enforcement.

STATE ENFORCEMENT MATRIX

Introduction:

This matrix is being circulated by the Working Group on Enforcement of the State-Federal FIFRA Implementation Advisory Committee (SFFIAC). SFFIAC is interested in compiling a matrix of the goals, priorities, and resources of State enforcement programs. Completion of the matrix is voluntary. All information will be treated confidentially. All data provided should be on a fiscal year basis, utilizing the last available year's figures. Your cooperation in filing out this form will be appreciated.

A. Goals and Purposes

[Insert a "yes" or "no" answer in the appropriate blank. Explain the rationale for "no" answers or add further goals and purposes on a separate sheet of paper.]

Goals and Purposes	Goal established	Goal consistent with legislative mandate	Goal consistent with allocation of resources
1. Allow maximum safe use of pesticides	______	______	______
2. Prevent harm to human life	______	______	______
3. Prevent harm to the environment	______	______	______
4. Ensure efficacy of products	______	______	______
5. Compliance with state and federal laws through education and training	______	______	______
6. Compliance with state and federal laws through enforcement actions	______	______	______
-compliance letter	______	______	______
-money penalties	______	______	______
-remedial performance	______	______	______

B. Enforcement Activities

[For the first four columns insert a "yes" or "no" answer in the appropriate blank. In the last column put the numerical ranking of that priority (e.g. for the six entries under "Establishments", rank each, one through six, from the most important to least important priority).]

Enforcement Activities	Enforcement jurisdiction established	Activity consistent with legislative mandate	Activity consistent with allocation of resources	Activity implemented	Rank order of progran priority
Establishments					
1. Technical formulators	______	______	______	______	______

B. Enforcement Activities, continued

Enforcement Activities	Enforcement jurisdiction established	Activity consistent with legislative mandate	Activity consistent with allocation of resources	Activity implemented	Rank order of program priority
2. End-use formulators					
3. Distributors-registrants					
4. Distributors-non-registrants					
5. Custom blenders					
6. Professional applicators					

	Enforcement jurisdiction established	Activity consistent with legislative mandate	Activity consistent with allocation of resources	Activity implemented	Rank of program priority
Use					
Class of Applicator:					
1. Certified pest control operators					
2. Certified private applicators (Farmers)					
3. Non-certified private applicators					
4. Households					
Activity:					
1. Agricultural					
a. Plant					
b. Animal					
2. Forest					
3. Ornamental. and turf					
4. Seed treatment					
5. Aquatic					
6. Right-of-way					
7. Industrial, institutional, structural, and health related					
8. Public health					
9. Regulatory					
10. Demonstration and research					

C. Enforcement Tools and Methodologies

[Answer "yes" or "no" to the following by inserting the answer in the appropriate blank if the State law or regulation contains the listed enforcement authorities or remedies].

1. Statutory Authorities

Statutory Authority	Statutory authority granted*	Have necessary inspection rights**	Have necessary resources: staffing	Have necessary resources: lab facilities	Presently exercising statutory authority
Production & Marketing					
Authority to:					
1. Impose registration & labeling requirements prior to commerce	______	______	______	______	______
2. Inspect establishments	______	______	______	______	______
3. Collect & examine samples	______	______	______	______	______
4. Review labels	______	______	______	______	______
5. Examine records of establishments	______	______	______	______	______
Use & Application					
Authority to:					
1. Take enforcement action for misuse:					
a.-dosage rate	______	______	______	______	______
b.-application method	______	______	______	______	______
c.-protective clothing	______	______	______	______	______
d.-drift	______	______	______	______	______
e.-unnamed crop	______	______	______	______	______
f.-unnamed pest	______	______	______	______	______
g.-unnamed site	______	______	______	______	______
h.-pre-harvest intervals	______	______	______	______	______
2. Enforce standards for container control:					
a.-storage	______	______	______	______	______
b.-disposal	______	______	______	______	______
c.-transport	______	______	______	______	______
d.-recycling	______	______	______	______	______

* including the right to promulgate rules and regulations necessary to exercise authority

**surveillance and monitoring creating a regulatory presence sufficient to meet compliance goals of enforcement program

C. Enforcement Tools and Methodologies, continued

1. Statutory Authorities, continued

Statutory authority	Statutory authority granted	Have necessary inspection rights	Have necessary resources: staffing	Have necessary resources: lab facilities	Presently exercising statutory authority
3. Regulate pesticide worker safety:					
a.-re-entry times	______	______	______	______	______
b.-mixing & loading	______	______	______	______	______
c.-supervision	______	______	______	______	______
d.-safety equipment	______	______	______	______	______
e.-protective clothing	______	______	______	______	______
f.-mechanical equipment	______	______	______	______	______
Investigation of Use and Misuse					
Authority to:					
1. Investigate use	______	______	______	______	______
2. Investigate misuse:	______	______	______	______	______
a.-accidents	______	______	______	______	______
b.-incidents	______	______	______	______	______
c.-worker illness	______	______	______	______	______
3. Investigate consumer complaints	______	______	______	______	______
Other Authorities					
1. Enter into co-operative enforcement agreements with Federal agencies	______	______	______	______	______
2. Enter into co-operative enforcement agreements with other State agencies	______	______	______	______	______

C. Enforcement Tools and Methodologies, continued

2. Remedies

	Statutory authority granted	Have necessary inspection rights	Have necessary resources: staffing	Have necessary resources: lab facilities	Presently exercising statutory authority
Categories of Enforcement Actions					
1. Citations	______	______	______	______	______
2. Warning Notices	______	______	______	______	______
3. Civil Penalty Warnings	______	______	______	______	______
4. Civil Prosecutions	______	______	______	______	______
5. Criminal Prosecutions	______	______	______	______	______
6. Stop Sale Order	______	______	______	______	______
7. Stop Use Order	______	______	______	______	______
8. Removal Order	______	______	______	______	______
9. Seizure	______	______	______	______	______
10. Formal Recalls	______	______	______	______	______
11. Import Detentions	______	______	______	______	______
12. License revocation	______	______	______	______	______
13. Other (list on separate sheet)					
Implementation of Enforcement Procedures:					
Procedures for:					
1. Laboratory analysis	______	______	______	______	______
2. Case preparation	______	______	______	______	______
3. Sample integrity and chain of custody	______	______	______	______	______
4. Administrative hearings	______	______	______	______	______
5. Assessment of penalties	______	______	______	______	______

D. Resources Currently Allocated to Pesticide Enforcement-Stratified by Program Activity (FY'76).

[In the first column insert the correct dollar amount spent for each activity utilizing the last available fiscal year's figures. If the dollar amount is unknown or unavailable, estimate the approximate amount and indicate that the figures are estimates. In the second and fifth columns insert the appropriate percentage. In the third and sixth columns answer "yes" or "no" in the proper blanks. In the forth column enter the number of man-years spent for each pesticide enforcement activity. If the correct number is unknown, make a reasonable estimate and indicate that the figures are estimates.

Program Activities	dollar amount	percent of total budget	budget consistent with enforcement priorities	number of man-years	percent of total man-years	man-years consistent with enforcement priorities
1. Product registration	______	______	______	______	______	______
2. Sampling & label review	______	______	______	______	______	______
3. Lab analysis & reports	______	______	______	______	______	______
4. Field surveillance on use	______	______	______	______	______	______
5. Establishment monitoring & surveillance	______	______	______	______	______	______
6. Certification of applicators	______	______	______	______	______	______
7. Administrative & clerical support	______	______	______	______	______	______
8. Other (list on separate sheet)	______	______	______	______	______	______

E. Past Enforcement Actions

[Enter the appropriate number of cases or dollar assessments in the corresponding blank].

	Civil	Criminal
Total Enforcement Actions		
1. Total No. of cases	______	______
2. Compliance obtained without initiating civil or criminal proceedings		
a.-compliance letter	______	______
b.-administrative action (license revocation)	______	______
c.-Remedial action	______	______
3. Formal civil or criminal proceedings initiated	______	______
Disposition of Civil or Criminal Proceedings		
1. Total no. of cases initiated	______	______
2. Criminal fines obtained	______	______
3. Final civil penalties obtained	______	______
4. Administrative actions	______	______
5. Proposed civil penalties pending final approval	______	______
6. Consent agreements signed	______	______
7. Total fines/penalties obtained or pending final approval	______	______
8. Cases dismissed	______	______
9. Zero penalty/fine or not reported	______	______
10. Action withdrawn or prosecution declined	______	______

APPENDIX B

A LITERATURE REVIEW OF HUMAN PERFORMANCE AND HUMAN FACTORS RESEARCH

The types of literature which would be desirable to support a behavior model and a taxonomy of factors leading to pesticide misuse would include not only examples of similar approaches to worker safety and environmental contamination problems, but also theoretical studies which would aid in organizing and evaluating such explanatory concepts as ignorance, carelessness, and motives related to misuse. Although no prior studies were found which dealt very specifically with the pesticide misuse problem, some works were reviewed which helped to give the present project a current, broader context.

In other words, it would be nice to turn to the professional literature for a solution to a complex economic-demographic-industrial-environmental problem and find ready-made concepts, procedures, and examples which would directly illuminate the original problem. Such an eureka experience rarely happens, but it is also rare that careful background research fails to produce at least some useful insights or published studies. The evaluation of the pesticide misuse problem, furthermore, has shifted rapidly in the past few years, so that searching for the comprehensive, pertinent research that is needed is destined to be a frustrating effort. The events in the rapid shift include the shift to organophosphate pesticides, the increasing number and variety of formulations, and the emergence of the PTSED with broad mandates.

Therefore, any body of research which deals with human behavior in a technological/organizational context should provide useful data and models for analyzing the pesticide misuse situation. This literature review includes research on:

- Human performance;
- Industrial safety and accidents;
- Human factors; and
- Job analysis, motives and behavior models.

Each of these categories extends across traditional disciplinary boundaries. For this reason, the journals within disciplines have been adequate to give a comprehensive view of trends and interrelated developments that involve the above categories, and thereby have importance for reducing pesticide misuse and damages.

HUMAN PERFORMANCE RESEARCH

A recent review of the engineering psychology and human performance literature is the report by Alluisi and Morgan.* They divide their review into two major categories -- applications and research -- with subcategories as shown:

Applications: Ergonomics and Human Factors Engineering	Research: Human Performance
1. Handbooks and texts	1. Methodology
2. Industrial work and production	2. Temporal influences on human performance
3. Health and safety	3. Environmental influences on human performance
4. Automotive and other transportation systems	4. Displays controls and information processing
5. Urban and environmental systems	5. Skilled performance and vigilance

These categories give some indication of difficulties which people have had in analyzing human behavior in various work contexts. For Alluisi and Morgan, the "applications" problem of human performance divides into "industrial work", "health and safety", "transportation", and "urban/environmental". But these categories are not completely independent of each other in terms of task or performance requirements. Thus the application of engineering psychology is divided into different contexts where separate application techniques are required.

The categories in the "research" literature give more insight into the types of behavior analysis which are used: temporal influence, vigilance, and information processing. The categories suggest approaches for development of a behavior taxonomy, which would enable the classification of behavior observed in pesticide misuse into categories which would lead to explanatory models and compliance strategies. In fact, the behavior taxonomy developed in the present pesticide misuse reduction project (i.e., Exhibit 7 or 22) is consistent with the categories named by Alluisi and Morgan.

One conclusion reached by Alluisi and Morgan is that the trend in analyzing human performance in various work contexts will be to place more analytical importance on the human resources aspects of the work and performance problems. This trend would mean that personal background factors, such

*Alluisi, E.A. and B.B. Morgan, Jr., "Engineering Psychology and Human Performance", in Annual Review of Psychology - 1976, Palo Alto, Annual Reviews, Inc. 1976.

as literacy, would be analyzed as part of a performance model of productivity, error rate, or safety. Such a trend, if it burgeons, will have broad significance for the pesticide misuse problem.

Another recent review of behavior model problems in human performance contexts is contained in a research project report by Theodore Barry and Associates, Inc.* This report is an analysis of workers and job hazards in the roofing industry, primarily in California. The research report concerns attitudes held by roofing workers, and the report contains various discussions of background issues (such as accident proneness) plus a review of research on psychological factors such as intelligence, personality and attitudes, in accidents.

With regard to these three factors, the conclusion to be drawn is that a precise model would require careful specification of attitudes, personalities and intelligence. Thus certain attitudes probably contribute to accidents. But the reviewers raise the question of whether negative attitudes arose to begin with because workers were forced into hazardous situations by management. The roofing industry report raises various issues and develops a series of study techniques such as personality inventories, interviews with workers, and actual "candid" motion pictures of roofing work situations. But the conclusions, such as the finding that the role of the supervisor is important in safety, indicate that additional work on behavior models is still needed.

INDUSTRIAL SAFETY AND ACCIDENT RESEARCH

In the review article by Alluisi and Morgan, the reviewers predict an increasing trend toward the synthesis and interpretation of human performance studies, in the form of "reviews" and compilations. In fact, since 1974, a series of new textbooks have appeared which give new structure to the industrial psychology discipline. This trend toward synthesis is welcome for anyone who is faced with a complex behavior modeling problem. And, speculatively speaking, it is likely that such a trend has been stimulated by the increasingly complex work situations associated, for example, with pesticide use.

The beginnings of the synthesis trend are traced to DeGreene**, but Alluisi and Morgan forecast that the trend will go far beyond his Systems Psychology. If so, it should be hoped that the interconnections among behavior factors will be well-established, for use in behavior models. DeGreene views models as a hierarchy (see Exhibit B-1) although his jump from "psychological tests" to "game simulation" could be difficult. The behavior model needed for pesticide use will presumably be in that portion of the hierarchy.

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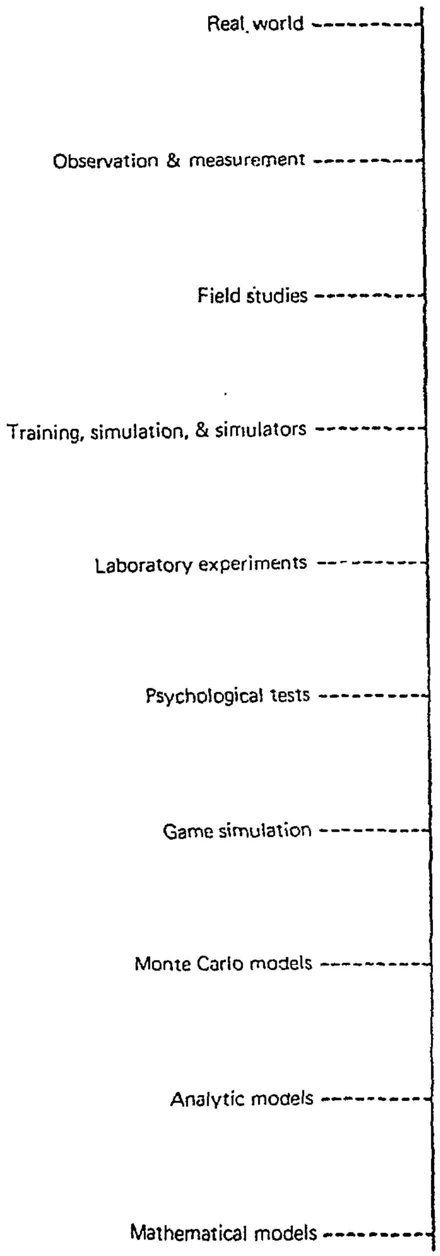
*Theordore Barry and Associates, Inc., Behavioral Analysis of Workers and Job Hazards in the Roofing Industry, (Contract HSM-99-72-121), U.S. Department of HEW, PHS-Center for Disease Control NIOSH, Division of Laboratories and Criteria Development, Cincinnati, Ohio, June, 1975.

**DeGreene, Kenyon B., Systems Psychology University of Southern California, Institute of Aerospace Safety and Management, McGraw-Hill Book Company, 1970.

Exhibit B-1: Systems Approach to Models



Source: DeGreene, _op. cit._, p. 97.

A simplified technique suggested by DeGreene might also be useful (see Exhibit B-2). Although the fault tree analysis tends to emphasize the mechanical operations of a system, it does identify the sequences of events where human action and error can occur. In the case of pesticide misuse, the events do not often involve a gross malfunction, such as a tank exploding, but fault trees could be used for analyzing such events as improper mixtures, or spray drift.

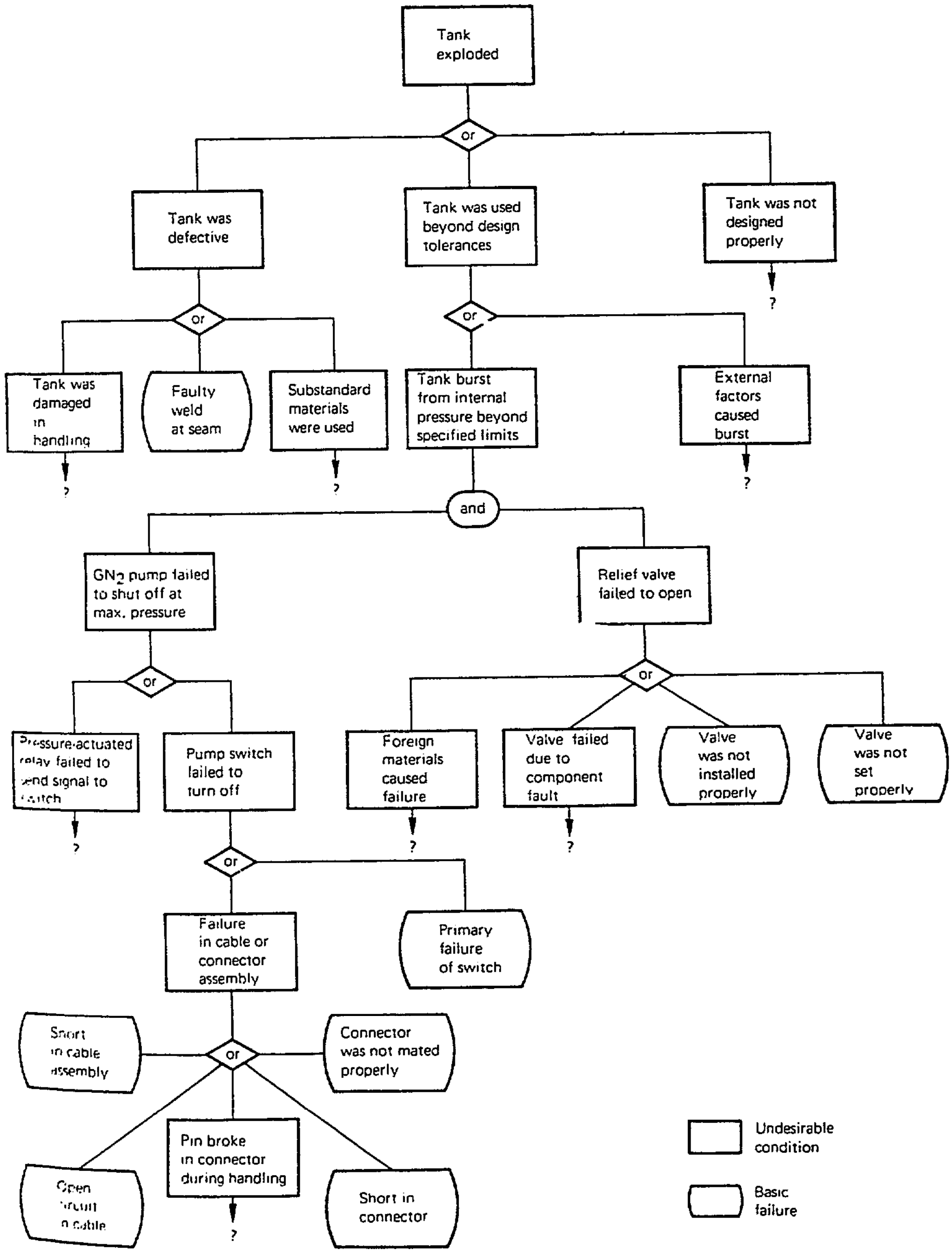
With regard to specific human mistakes, DeGreene suggests the molar-level error behaviors shown in Exhibit B-3. This list is comprehensive, possibly because the error behaviors are "abstract" in the sense that they could apply to most man-machine systems, although the context is vaguely military. This type of behavior taxonomy is not useful for analyzing complex motives or underlying factors such as stress and fatigue. In other words, the approach described by DeGreene is intended to apply to certain types of man-machine systems in which equipment malfunctions are well-separated from operator errors, and modeling can be made very abstract.

A broadly human resource approach to accidents and safety is that taken by Zeller.* The philosophy of accidents given by Zeller is well-constructed and holds considerable relevance to the pesticide misuse context:

> "There is some confusion as the exactly what an accident is. ... Review of accident statistics indicates vastly different criteria for accident reporting. For this reason, statistical comparisons and statistical analyses can be accepted only with reservation until there is assurance that the data sources are comparable. In the broadest definition, any unexpected event might be considered an accident; for practical purposes, however, prevention is most applicable to those mishaps in which either damage or injury is sustained. Practical considerations also have limited requirements for accident reporting to those in which some minimum cost is involved. This criterion has been modified and refined to fit the needs of the reporting agency. Within the Air Force, for example, mishaps may be categorized as major or minor accidents or incidents depending on some criterion of repair costs (Directorate of Aerospace Safety, 1966), which may be in terms of dollars or time to repair or change constituents. This criterion is modified further in terms of the basic complexity of the equipment. A mishap resulting in damage to an expensive supersonic bomber might not be classified in this scale as an accident because of the repair cost relative to the total value of the equipment, yet the actual dollar cost in question might be comparable to that involved had an entire smaller aircraft been destroyed.

*Zeller, A.F., "Accidents and Safety", Chapter 4 in K.B. DeGreene (ed.), Systems Psychology, New York: McGraw-Hill, 1970, pp. 131-150.

Exhibit B-2: Fault-Tree Analysis of System Reliability



Source: DeGreene, op. cit., p. 117.

Exhibit B-3: Molar-Level Error Behaviors

Psychological Factors (learning categories)	Error Behaviors
Sensing, detecting, identifying, coding, classifying	Failing to monitor field Failing to record or report signal change Recording or reporting signal change when none has occurred Recording or reporting signal change in the wrong direction Falling to record or report the appearance of a target Recording or reporting a target when none is in the field Assigning target to wrong class
Chaining or rote sequencing	Making a below-standard response Omitting a procedural step Inserting unnecessary procedural step Mis-ordering procedural steps
Estimating with discrete responding; estimating with continuous responding (tracking)	Failing to respond to super-threshold target change Responding to sub-threshold target change Premature response to target change Late response to target change Inadequate magnitude of control action Excessive magnitude of control action Inadequate continuance of control action Excessive continuance of control action Wrong direction of control action
Logical manipulation, rule using, decision making	Incorrect value weighting of responses to contingency Failing to apply an available rule Applying correct, but inappropriate, rule Applying fallacious rule Failing to obtain or apply all relevant decision information Failing to identify all reasonable alternatives Making unnecessary or premature decision Delaying decision beyond the time it is required
Problem solving	Formulating erroneous rules or guiding principles Failing to use available information to derive needed solution Accepting inadequate solution as final

Source: DeGreene, op. cit., p. 115.

"From the standpoint of cause and prevention, however, there is often little difference between circumstances that lead to destruction and those that result in only minor damage. Since the analyst can profit from these marginal events in defining remedial measures, it is highly desirable that the information be obtained. Various organizations have recorded such data in different ways; one of the simplest is to define these marginal events as incidents, which are not computed in the overall accident rates, but which are available for study by those with accident prevention per se.

Another category of mishap - the hazardous condition or near miss - might also serve to alert personnel to incipient accidents. Near-miss and hazard reporting has been attempted by various groups. At this point, however, the problem of subjective choice of events to be reported intrudes so that near-miss data are of more questionable value than those obtained from accident experience. As pointed out in earlier chapters, human operators are often loath to report hazards they themselves have created. Near-miss information, thus, is characterized by a maximum of environmental- and material oriented items with a minimum of operator-induced hazards. An analysis of hazard reports compared with an analysis of accidents for the same period of time may well indicate differences in distribution. This suggests that remedial measures aimed at preventing hazards may accomplish only that, while failing to prevent accidents.

... It is axiomatic that effective prevention must have a focal point of application. This implies that the probable cause of future accidents can be predicted. This, in turn, implies that the causes of past accidents have been determined. In practice, the determination of the cause of an accident is no simple matter. It becomes increasingly apparent as any accidental occurrence is examined that there is seldom a single, clear-cut cause, more often there are multiple causes, which may be immediate or remote.

... The most commonly designated cause of accidents is human error. In accidents where material failure is recognized, it is often quite possible to continue tearing down the equipment until the precise portion that failed is isolated and the cause of the failure, whether it be corrosion, stress, faulty load conceptualization or other factors can be determined and redesign proposed. In cases of human error, however, the static statement that a human being failed provides no guidance to future improvement. The need to reduce human error to its basic constituents as a means of obtaining insight into the causes of these failures has resulted in various approaches to segmenting human behavior for analytical purposes. (pp. 132-134)"

This discussion gives a clear logic for the analysis of behavior in such a way that accident occurrences can be understood. In further discussion, Zeller points out that the recognition that accidents cannot be entirely prevented, dictates that efforts be made to minimize damage.

Zeller's analysis of accident related behavior proceeds with the checklist shown in Exhibit B-4. This checklist is oriented toward aircraft accidents, but the eight major categories could apply to any man-machine system. It is not surprising that the items presented are a wide selection of single specific conditions (hypozia, navigational error) and broad complex phenomena (failure to use accepted procedures, misinterpreted communications), plus a few plain "excuses" (get-homeitis, hurried departure). In other words, this list is a combination of psychophysiology and folklore, and if a similar list were developed and used for pesticide misuse incidents, it would require careful statistical validation.

A different approach to accident analysis and to the development of behavior taxonomies has been developed by Brown.* This approach is described in a new book which continues the "systems" approach of DeGreene, and which synthesizes the fault tree analysis described by DeGreene, and the accident cost (damages) measurement suggested by Zeller. Rather than compile a behavior list such as the one by Zeller, Brown suggests using the coded lists prepared by the American National Standard Institute (ANSI) including the source of injury, the accident type, the hazardous condition, and the unsafe act classification (see Exhibit B-5).

The ANSI list suffers some of the same problems described and illustrated by Zeller. For example, one major category of unsafe acts is "inattention to footing or surroundings". If an accident were coded with this attribute, it is likely that additional investigation would be needed before enough insight were gained to begin efforts to prevent recurrence. Nevertheless, the ANSI system provides a complete way of coding accidents on several dimensions, and Brown presents a way of analyzing these codes statistically. Such an analysis would constitute a statistical model of pesticide misuse, if the codes were applicable to the pesticide misuse context.

These ANSI codes are partly relevant to pesticide misuse, since the "unsafe acts" include "failure to wear safe personal attire", and "failure to use available personal protective equipment".

But these unsafe act codes do not provide for the integration of the "human resources" concept into the accident or misuse analysis. It is not clear how level of training, team organization, or stress will have a place in Brown's "logical analysis", which is a preliminary step to fault tree analysis. And, for better or worse, the factors identified by Theodore Barry and Associates, such as intelligence, personality and attitudes, are not identifiable within the Brown system.

The systems approach described in the preceding discussion thus leaves some gaps to be filled before there can be a well-documented (literature based) effort at behavior modeling in the pesticide misuse context. As noted above, this systems approach is likely to continue with more synthesis of research

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*Brown, David B., Systems Analysis and Design for Safety: Safety Systems Engineering, Prentice Hall, Inc., Englewood Cliffs, New Jersey, 1976.

Exhibit B-4: Checklist for Accident Behavior

III. PSYCHOPHYSIOLOGICAL AND ENVIRONMENTAL FACTORS

INSTRUCTIONS: Complete on all occupants of aircraft, all injured persons, and all persons possibly contributing to the cause of the mishap. Supervisory factors attributed to persons not in the aircraft and such factors as design or weather should be reported only for the person in primary control of the aircraft. Factors contributing to injury during mid-air collisions, crash landings, ditchings, etc., are to be considered part of survival phase. Use codes at right to show only those factors present or contributing in each phase.

PHASES OF MISHAP
A – ACCIDENT
E – ESCAPE
S – SURVIVAL (Includes parachute landings)
R – RESCUE

FACTOR IMPORTANCE
D – DEFINITELY CONTRIBUTED
S – SUSPECTED FACTOR
P – CONDITION PRESENT, BUT DID NOT CONTRIBUTE TO ACCIDENT OR INJURY.

FACTORS		A	E	S	R
1. SUPERVISORY FACTORS					
INADEQUATE BRIEFING	101				
ORDERED/LED ON FLIGHT BEYOND CAPABILITY	102				
POOR CREW COORDINATION	103				
OTHER *(Specify)*	199				
2. PRE-FLIGHT FACTORS					
FAULTY FLIGHT PLAN	201				
FAULTY PRE-FLIGHT OF AIRCRAFT	202				
FAULTY PREPARATION OF PERSONAL EQUIP.	203				
HURRIED DEPARTURE	204				
DELAYED DEPARTURE	205				
INADEQUATE WEATHER ANALYSIS	206				
OTHER *(Specify)*	299				
3. EXPERIENCE/TRAINING FACTORS					
INADEQUATE TRANSITION	301				
LIMITED TOTAL EXPERIENCE	302				
LIMITED RECENT EXPERIENCE	303				
FAILURE TO USE ACCEPTED PROCEDURES	304				
OTHER *(Specify)*	399				
4. DESIGN FACTORS					
DESIGN OF INSTRUMENTS, CONTROLS	401				
LOCATION OF INSTRUMENTS, CONTROLS	402				
FAILURE OF INSTRUMENTS, CONTROLS	403				
COCKPIT LIGHTING	404				
RUNWAY LIGHTING	405				
LIGHTING OF OTHER AIRCRAFT	406				
PERSONAL EQUIPMENT INTERFERENCE	407				
WORKSPACE INCOMPATIBLE WITH MAN	408				
OTHER *(Specify)*	499				
5. COMMUNICATIONS PROBLEMS					
MISINTERPRETED COMMUNICATIONS	501				
DISRUPTED COMMUNICATIONS	502				
LANGUAGE BARRIER	503				
NOISE INTERFERENCE	504				
OTHER *(Specify)*	599				
6. PSYCHOPHYSIOLOGICAL FACTORS					
FOOD POISONING	601				
MOTION SICKNESS	602				
OTHER ACUTE ILLNESS	603				
OTHER PRE-EXISTING DISEASE/DEFECT	604				
GET-HOMEITIS	605				
HANGOVER	606				
SLEEP DEPRIVATION	607				
FATIGUE, OTHER	608				
MISSED MEALS	609				
DRUGS PRESCRIBED BY MEDICAL OFFICER	610				
DRUGS, OTHER	611				
ALCOHOL	612				
NAME OF INDIVIDUAL					

FACTORS		A	E	S	R
VISUAL ILLUSIONS	613				
UNCONSCIOUSNESS	614				
DISORIENTATION/VERTIGO	615				
HYPOXIA	616				
HYPERVENTILATION	617				
DYSBARISM	618				
CARBON MONOXIDE POISONING	619				
BOREDOM	620				
INATTENTION	621				
CHANNELIZED ATTENTION	622				
DISTRACTION	623				
PREOCCUPATION WITH PERSONAL PROBLEMS	624				
EXCESSIVE MOTIVATION TO SUCCEED	625				
OVERCONFIDENCE	626				
LACK OF SELF-CONFIDENCE	627				
LACK OF CONFIDENCE IN EQUIPMENT	628				
APPREHENSION	629				
PANIC	630				
OTHER *(Specify)*	699				
7. ENVIRONMENTAL FACTORS					
ACCELERATION FORCES, IN-FLIGHT	701				
ACCELERATION FORCES, IMPACT	702				
DECOMPRESSION	703				
VIBRATION	704				
GLARE	705				
SMOKE, FUMES, ETC.	706				
HEAT	707				
COLD	708				
WIND BLAST	709				
VISIBILITY RESTRICTION–WEATHER,HAZE,DARKNESS	710				
VISIBILITY RESTRICTION–ICING,WINDOWS FOGGED,ETC.	711				
VISIBILITY RESTRICTION–DUST, SMOKE, ETC., IN ACFT	712				
WEATHER, OTHER THAN VISIBILITY RESTRIC.	713				
OTHER *(Specify)*	799				
8. OTHER FACTORS TO BE CONSIDERED					
HABIT INTERFERENCE, USED WRONG CONTROL	801				
CONFUSION OF CONTROLS, OTHER	802				
MISREAD INSTRUMENT(S)	803				
MISINTERPRETED INSTRUMENT READING	804				
MISLED BY FAULTY INSTRUMENT	805				
VISUAL RESTRICTION BY EQUIP STRUCTURES	806				
TASK OVERSATURATION	807				
INADEQUATE COORDINATION OR TIMING	808				
MISJUDGED SPEED OR DISTANCE	809				
SELECTED WRONG COURSE OF ACTION	810				
DELAY IN TAKING NECESSARY ACTION	811				
VIOLATION OF FLIGHT DISCIPLINE	812				
NAVIGATIONAL ERROR	813				
INADVERTENT OPERATION SELF INDUCED	814				
INADVERTENT OPERATION MECHANICALLY INDUCED	815				
OTHER *(Specify)*	899				
SERVICE NO.					

Source: Zeller, op. cit., page 146.

Exhibit B-5: Unsafe Act Classification (Selected from ANSI 716.2-1962 (/969)

Code

050 *Cleaning, oiling, adjusting, or repairing of moving, electrically energized, or pressurized equipment* (Do not include actions directed by supervision)
- 051 Caulking, packing, etc, of equipment under pressure (pressure vessels, valves, joints, pipes, fittings, etc)
- 052 Cleaning, oiling, adjusting, etc, of moving equipment
- 056 Welding, repairing, etc, of tanks, containers, or equipment without supervisory clearance in respect to the presence of dangerous vapors, chemicals, etc
- 057 Working on electrically charged equipment (motors, generators, lines, etc)
- 059 NEC

100 *Failure to use available personal protective equipment* (goggles, gloves, masks, aprons, hats, lifelines, shoes, etc)

150 *Failure to wear safe personal attire* (wearing high heels, loose hair, long sleeves, loose clothing, etc)

200 *Failure to secure or warn*
- 201 Failure to lock, block, or secure vehicles, switches, valves, press rams, other tools, materials, and equipment against unexpected motion, flow of electric current, steam, etc
- 202 Failure to shut off equipment not in use
- 203 Failure to place warning signs, signals, tags, etc
- 205 Releasing or moving loads, etc, without giving adequate warning
- 207 Starting or stopping plant vehicles or equipment without giving adequate warning
- 209 NEC

250 *Horseplay* (distracting, teasing, abusing, startling, quarreling, practical joking, throwing material, showing off, etc)

300 *Improper use of equipment*
- 301 Use of material or equipment in a manner for which it was not intended
- 305 Overloading (vehicles, scaffolds, etc)
- 309 NEC

350 *Improper use of hands or body parts*
- 353 Gripping objects insecurely
- 355 Taking wrong hold of objects
- 356 Using hands instead of hand tools (to feed, clean, adjust, repair, etc)
- 359 NEC

400 *Inattention to footing or surroundings*

450 *Making safety devices inoperative*
- 452 Blocking, plugging, tying, etc, of safety devices
- 4.53 Disconnecting or removing safety devices
- 454 Misadjusting safety devices
- 456 Replacing safety devices with those of improper capacity (e.g. higher amperage electric fuses, low capacity safety valves, etc)
- 459 NEC

Exhibit B-5: Unsafe Act Classification (Selected from ANSI 716.2-1962 (/969) (Continued)

Operating or working at unsafe speed
- 502 Feeding or supplying too rapidly
- 503 Jumping from elevations (vehicles, platforms, etc)
- 505 Operating plant vehicles at unsafe speed
- 506 Running
- 508 Throwing material instead of carrying or passing it
- 509 NEC

550 *Taking unsafe position or posture*
- 552 Entering tanks, bins, or other enclosed spaces without proper supervisory clearance
- 555 Riding in unsafe position (e.g. on platforms, tailboards, on running boards of vehicles; on forks of lift truck; on hook of crane; etc)
- 556 Unnecessary exposure undersuspended loads
- 557 Unnecessary exposure to swinging loads
- 558 Unnecessary exposure to moving materials or equipment
- 559 NEC

600 *Driving errors* (by vehicle operator on public roadways)
- 601 Driving too fast or too slowly
- 602 Entering or leaving vehicle on traffic side
- 603 Failure to signal when stopping, turning, backing
- 604 Failure to yield right of way
- 605 Failure to obey traffic control signs or signals
- 606 Following too closely
- 607 Improper passing
- 608 Turn from wrong lane
- 609 NEC

650 *Unsafe placing, mixing, combining, etc*
- 653 Injecting, mixing, or combining one substance with another so that explosion, fire, or other hazard is created (e.g. injecting cold water into hot boiler, pouring water into acid, etc)
- 655 Unsafe placing of vehicles or material moving equipment (i.e. parking, placing, stopping, or leaving vehicles, elevators, or conveying apparatus in unsafe position for loading or unloading)
- 657 Unsafe placement of materials, tools, scrap, etc (i.e. so as to create tripping, bumping, slipping hazards, etc)
- 659 NEC

750 *Using unsafe equipment* (e.g. equipment tagged as defective or obviously defective. Do not include the use of inherently hazardous material for its intended purpose unless it was obviously defective. Do not include use of defective material or equipment when the defect was hidden and not obvious to the user)

900 *Unsafe act, NEC*

993 *No unsafe act*

999 *Unclassified-inadequate data*

results from various disciplines, and techniques such as Fault Tree Analysis and Brown's Logic Analysis can undoubtedly provide the basis for the development of behavior models. But further synthesis of research in industrial psychology is required before the concept of "human resources" is brought into the behavior modeling context.

There are several areas in "traditional" industrial psychology and safety which have contributed to the emergence of the systems/synthesis/human resources trend. Certainly the behavior taxonomies developed by Fleishman* and Miller** have provided a basis to develop the taxonomies of Zeller (shown above) and others. The taxonomy of Fleishman (see Exhibit B-6) is specifically psychophysical in that it involves the performance of very specific actions to implied task requirements.

Broader connections among task requirements, environmental conditions, and "human resource" factors and attributes have been the subject of extensive research, and the interaction (collision, perhaps) of these two categories of research has led to the current emphasis on synthesis. The continuing importance of this environment/human resource work is emphasized by the content of a new textbook in which the systems approach is put aside in favor of the traditional approach.*** The Landy and Trumbo book emphasizes the importance of developing specific accident data, rather than resorting to excuses such as accident proneness or human error. Their models of stressor effects do not clearly connect with a particular set of human resource factors (e.g., training, sex) although a signal detection task is mentioned. The presence of a review of research in which human resource factors are studies are nevertheless significant, although a more extensive such review is given in an earlier book by Siegel and Lane.****

HUMAN FACTORS RESEARCH

It is possible to view the pesticide misuse field as requiring basic new research in human factors. Research of this type is described by Meister.***** Meister gives six outlines for classifying (organizing) such research:

- Equipment parameter;
- Personnel parameter;

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*Fleishman, E.A., "Human Abilities and the Acquisition of Skill". in E.A. Bilodeau, (ed.), Acquisition of Skill, New York: Academic Press; 1966.

**Miller, R.B., "Task Taxonomy: Science or Technology?", Ergonomics, Volume 10, 1967, pp. 167-176.

***Landy, Frank J. and Trumbo, Don A., Psychology of Work Behavior, The Dorsey Press, 1976.

****Lane, Irving M. and Seigel, Laurence, Psychology in Industrial Organizations, Richard D. Irwin, Inc., 1974.

*****Meister, D., Human Factors: Theory and Practice, New York: Wiley Interscience, Chapter 4.

Exhibit B-6: Taxonomy of Abilities

The taxonomy of the more important abilities resulting from this programmatic research as briefly described by Fleishman (1966):

Control Precision: This factor is common to tasks which require fine, highly controlled, but not overcontrolled, muscular adjustments, primarily where larger muscle groups are involved...

Multilimb Coordination: This is the ability to coordinate the movements of a number of limbs simultaneously...

Response Orientation: This ability factor . . . appears to involve the ability to select the correct movement in relation to the correct stimulus, especially under highly speeded conditions...

Reaction Time: This represents simply the speed with which an individual is able to response to a stimulus when it appears...

Speed of Arm Movement: This represents simply the speed with which an individual can make a gross, discrete arm movement where accuracy is not the requirement...

Rate Control: This ability involves the making of continuous anticipatory motor adjustments relative to changes in speed and direction of a continuously moving target or object...

Manual Dexterity: This ability involves skillful, well-directed arm-hand movements in manipulating fairly large objects under speed conditions...

Finger Dexterity: This is the ability to make skill-controlled manipulations of tiny objects involving, primarily, the fingers...

Arm-Hand Steadiness: This is the ability to make arm-hand positioning movements where strength and speed are minimized; the critical feature, as the name implies, is the steadiness with which such movements can be made...

Wrist, Finger Speed: This ability has been called "tapping" in many previous studies...

Aiming: This ability appears to be measured by printed tests which provide the subject with very small circles... The subject typically goes from circle to circle placing one dot in each circle as rapidly as possible (pp. 152-156).

Source: Fleishman, E.A., Human Abilities and the Acquisition of Skill in E.A. Bilodeau (ed.), Acquisition of Skill, New York: Academic Press, 1966.

- Functions/tasks;
- The environment;
- Measures of system operation; and
- Methods of data collection and analysis.

Meister's "functions/tasks" outline (see Exhibit B-7) is reminiscent of the behavior taxonomies discussed above, and could well serve as a guide to specific research on pesticide application tasks.

Similarly, the outlines for "environment" (see Exhibit B-8) and "measures" (see Exhibit B-9) give a good basic structure for designing pesticide use experiments. From these outlines, a set of "specific" outlines could be made which would give a plan for a research program for pesticide use. But this specific research outline could serve a preliminary function of guiding a complete review of all human factors research which could be relevant to pesticide use.

A preliminary review of human factors research has not revealed studies specific to pesticide use. A recent report on respirators and masks, for example, gives a review of types of breathing hazards and procedures for using masks.* In another report, the researchers found that 70 percent of farmers in a county-wide farm survey disposed of pesticide containers in woods or fields. But no data were given on the human factors, such as environment, organization context, or cognitive errors. In a third report on labels,** a series of possible errors in reading labels were discussed, but no data on the human factors involved were given.

Admittedly, the above references were intended as "practical" reports, and not as research reports. However, it is possible that if research data on human factors had been available, the researchers would have cited these data to support their recommendations.

JOB ANALYSIS, MOTIVES, AND
BEHAVIOR MODELS RESEARCH

At first glance, it might seem that a series of techniques called "job analysis" might serve as a link between the systems/synthesis approach to behavior models, or at least might aid in the development of human factors data on pesticide use tasks. The work of McCormick et.al.*** in producing the position analysis questionnaire (see Exhibit B-10) is again reminiscent of various systems approaches to task analysis.**** These two lines of effort have

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*Law, S.E., "Respirators and Masks", Agricultural Engineering, November, 1972, pp. 12-14.

**St. Aubin, F., "The Label and You", Pest Control, April, 1974, pp. 15-16.

***McCormick, E.J., Jeanneret, P., and Mecham, R.C., "A Study of Job Characteristics and Job Dimensions as Based on the Position Analysis Questionnaires", Journal of Applied Psychology 1972, 36, Monograph, pp. 347-368.

****DeGreene, op.cit., pp. 109-110.

Exhibit B-7: Classification Scheme for Human Factors Research Studies: Functions/Tasks

1. Type
   (a) Operate Equipment
   (b) Maintain Equipment
   (c) Perform Manual Tasks in Support of (a) and (b)[1]
   (d) Communicate Information
   (e) Instruct Personnel
   (f) Two or More of the Above in Combination.

2. Behaviors Required
   (a) Sensory/Perceptual
   (b) Motor
   (c) Sensory/motor (psychomotor)[2]
   (d) Cognitive
   (e) Communication
   (f) Two or More of the Above in Combination.

3. Task Characteristics
   (a) Task Composition[3]
      (1) Individual
      (2) Group
   (b) Task Duration[4]
   (c) Task Criticality (effect on mission performance, system availability, etc.)
   (d) Task Frequency of Occurrence
   (e) Task Interrelationships[5]
      (1) Independent
      (2) Dependent
      (3) Concurrent
      (4) Sequential
   (f) Task Length (e.g., number of procedural steps)
   (g) Task Pacing[6]
      (1) System/Machine Paced
      (2) Individual/Self-Paced

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[1]For example, recording failure information on forms preparatory to or following troubleshooting or drawing replacement parts from supply. In other words, activities which, in the strict sense of the term, are not actually equipment operation or maintenance but which are required to perform them.

[2]This category involves (2a) and (2b) in combination as in tracking a target using a cathode-ray-tube or typing a letter; (2a) and (2b) individually refer to sensory and motor activities performed alone.

[3]Is the task one which an individual or a group performs?

[4]How long the task takes either in absolute time (e.g., 5 seconds) or in descriptive comparative terms (e.g., prolonged, momentary).

[5]The performance of an individual task may depend upon the performance of one or more prior tasks (the task then is dependent); or it may not depend upon prior tasks (it is then independent). One task may be performed at the same time a second task is performed (it is then concurrent). A task may be either dependent or independent as well as concurrent or sequential.

[6]Refers to speed and accuracy criteria imposed on task performance. If the task is self-paced, the operator performs with the speed and accuracy he feels are most comfortable; if it is system/machine paced, the operator works and accuracy standards established by someone other than himself.

Source: Meister, *op. cit.*, p. 114.

Exhibit B-8: Classification Scheme for Human Factors Research Studies: The Environment

1. Physical Location
   (a) Space
   (b) Air
   (c) Sea Surface
   (d) Sea Subsurface
   (e) Ground

2. Parameters Involved
   (a) Temperature
   (b) Noise
   (c) Lighting
   (d) Acceleration
   (e) Vibration
   (f) Atmosphere

3. Work Context[1]
   (a) Civilian
   (b) Military
   (c) Both

4. Measurement Context[2]
   (a) Operational
   (b) Quasi-operational (e.g., field test)
   (c) Design/Development
      (1) Mockups
      (2) Simulators
      (3) Prototype Equipment
   (d) Laboratory

---

[1]The system may be a military or a civilian one or a military system operated by civilians (often found in prototype testing of advanced equipment).

[2]Refers to the environment in which measurements are made. Operational refers to measures taken of a system performing in its designated functioning environment (e.g., on a war mission). Quasi-operational refers to a field test or exercise situation which resembles, or may even be, the operational environment (e.g., field trials for a new submarine), but which is experimentally controlled in its operations or the manner in which they are carried out. Design/development is the contractor's engineering environment, in which tests may be performed using mockups or simulators and on prototype equipment. Laboratory tests are self-explanatory.

Source: Meister, op. cit., p. 120.

Exhibit B-9: Classification Scheme for Human Factors Research Studies: Measures

1. Criteria Employed[1]
   (a) System
      (1) Terminal[2]
      (2) Intermediate[3]
   (b) Individual
      (1) Terminal
      (2) Intermediate
   (c) Behavioral[4]
   (d) Psychological[5]
   (e) Physiological[6]

2. Types of Measures
   (a) Objectives
      (1) Individual Measures
         a. Performance Accuracy
         b. Errors (magnitude/frequency/rate)
         c. Event Occurrence
            1. Frequency
            2. Percentage
            3. Mean
         d. Response Time (duration, reaction time)
         e. Accidents
         f. Critical Incidents[7]
         g. Physiological (e.g., heart rate)
      (2) System Measures[8]
         a. Performance Accuracy (e.g., "miss distance")
         b. Performance Reliability
            1. Probability of Error Occurrence
            2. Probability of Task Completion
            3. Percentage/Frequency of Human-iniated malfunctions
         c. Event Occurrence[9]
            1. Frequency
            2. Percentage
            3. Mean
         d. Performance Duration (e.g., time required for system to complete mission)
   (b) Subjective
      (1) Ratings/Rankings
      (2) Opinions (e.g., survey/interview response)

3. Descriptive Characteristics[10]
   (a) Quantitative
   (b) Qualitative

Exhibit B-9: Classification Scheme for Human Factors Research Studies: Measures (Continued)

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[1]System criteria describe system (equipment plus crew) as distinct from individual (operator alone) performance measures.

[2]Terminal criteria are those that describe functions and tasks representing mission completion. For example, in the Air Antisubmarine Warfare (AASW) mission the end product of a series of complex tactical operations by the crew is the dropping of depthcharges against the submarine. The terminal criterion is whether or not a kill is achieved; this is in turn a function of other variables such as distance from the submarine when the charge is dropped.

[3]Intermediate criteria describe functions/tasks that lead up to or implement the completion of the mission but do not themselves describe mission completion. For example, in the AASW mission referred to, the mission segments preceding the kill are search, detection, localization of the target and dropping of barrier sonobuoys.

[4]A behavioral criterion is one which relates to or describes human performance in a system context (e.g., the speed with which the AASW operator detects the target and the accuracy with which he classifies its "signature").

[5]The psychological criterion refers to individual human performance which is not necessarily mission-related, such as motivational or attitudinal reactions e.g., boredom, satisfaction, or even physical reactions like squirming).

[6]A physiological criterion relates to the human's body functions (e.g., blood pressure changes in astronauts during lift-off) which are correlated with and in part describe his performance in accomplishing system requirements. In considering a system event like the AASW mission referred to above, all or some of these criteria may apply simultaneously, depending upon which aspect of the event we are considering (e.g., the mission as a whole, a segment of the mission, a crew task, or the behavior of a single crewman).

[7]A critical incident is some distinctive representative, or frequently occurring behavior which illustrates is summary fashion a particular facet of the individual's behavior almost in the way the few penstrokes of an artist will catch the essence of his subject's face.

[8]In differentiating between performance accuracy and performance reliability, we define accuracy as referring to the single event (e.g., the accomplishment of a task or mission goal); reliability refers to the frequency or probability of accomplishing that event (e.g., the task over repeated occurrences).

[9]Even occurrence describes phenomena occurring during the mission which may or may not implement the system mission. An individual event occurrence may be the number of updating range reports made by an AASW operator during a mission. System event occurrence may describe the frequency of AASW crew communications as a whole during that mission.

[10]Measures may be either quantitative or non-quantitative (i.e., qualitative). Qualitative measures may be either objective or subjective just as quantitative measures may be. A running verbal description of events occurring during a test is an example of qualitative objective measure. The temperature of the room in which work is being performed is an example of quantitative objective measure. The ranking of a group of maintenance technicians in terms of skill level would be an example of quantitative subjective measure. What makes a measure quantitative is the metric in which it is expressed rather than the means by which its data are gathered. Interview responses are qualitative (verbal) and subjective (because they are expressions of subjective feeling) but become quantitative if, for example, the researcher were to make a frequency county of the number of times the pronoun "I" was used by interviewees.

Source: Meister, op. cit., pp. 124-125.

Exhibit B-10: Position Analysis Categories

1. Information Input

   Sources of Job Information
   Discrimination and Perceptual Activities

2. Mediation Processes

   Decision Making and Reasoning
   Information Processing
   Use of Stored Information

3. Work Output

   Use of Physical Devices
   Integrative Manual Activities
   General Body Activities
   Manipulation Coordination Activities

4. Interpersonal Activities

   Communications
   Interpersonal Relationships
   Personal Contact
   Supervision and Coordination

5. Work Situation and Job Context

   Physical Working Conditions
   Psychological and Sociological Aspects

6. Miscellaneous Aspects

   Work Schedule, Method of Pay, and Apparel
   Job Demands
   Responsibility

Source: McCormick, *et al.*, *op. cit.*

not, however, produced the broad environment/human resource/human factors taxonomy needed for complex behavior modeling in the pesticide use context.

Meanwhile, the job analysis approach has been widely used in personnel management, including both personnel selection and in design of training programs. This body of research and practice, although not as modeling oriented as the systems field, cannot be overlooked by the pesticide misuse researcher, especially because of the emphasis on attitudes and motivation in the personnel management field.* Unfortunately, it is not always clear that the personnel manager's ideas of incentives are consistent with current psychological theory.**, ***

*Landy and Trumbo, op.cit., p. 293 ff; Siegel and Lane, op.cit., p. 283 ff.

**Gallistel, C.R., "Motivation as Central Organizing Process: The Psychophysical Approach to its Functional and Neurophysiological Analysis", in James K. Cole and Theo Sondregger (eds.), Nebraska Symposium on Motivation, 1974, Lincoln: University of Nebraska Press, 1975.

***Capaldi, E.D., Hovancik, J.R., and Friedman F., "Effects of Expectancies of Different Reward Magnitudes in Transfer from Noncontingent Pairings to Instrumental Performance", Learning and Motivation, Volume 7, 1976, pp. 197-210.

APPENDIX C

A LITERATURE REVIEW OF INDUSTRIAL SAFETY RESEARCH

In recent years, increasing numbers of safety officials have recognized the importance that a worker's behavior has in preventing or causing unsafe conditions and accidents (or pesticide misuse using the current study's language). One approach used in industrial psychology to prevent unsafe behavior rests on the basic premise that all industrial workers have a strong previously-learned response to specific money rewards, i.e., to specific amounts of money offered as safety incentives. However, the human relations movement in industry has _also_ noted that interpersonal actions among employees are at least as important as are the salaries and the financial benefits in affecting job attitudes and productivity, including safety performance. In other words, although the financial incentives (wages) are _viewed_ as important, and probably _are_ important, the overall social-occupational workplace context contains incentives equally important to high productivity, and to accident prevention.*

The human relations movement incorporates a broad range of concepts and work conditions which are thought to act as incentives, including general strategies such as job design, job enlargement and hierarchical involvement, and specific variables such as size of work group and demographic similarities among workers. In this context (i.e., the human relations literature) a number of terms, in addition to "incentives", are used to describe the industrial workers' behavior in what is sometimes called the "sociotechnical environment".

From the human relations point of view, therefore, it is inappropriate to design compliance strategies based on "single variable" incentives such as monetary rewards, promotion potential, or improved fringe benefits. In fact, in a recent review of research in organization development,** little if any attention is given to research on these types of incentives. Instead, the categories of job satisfaction and motivation research include: Sociotechnical Systems; Job Design and Job Enlargement; Job Enrichment; Human Physiological Approaches; Survey Feedback; Group Development Intervention; and Intergroup Relations Development.

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*Locke, E.A., "Personnel Attitudes and Motivation" in M.R. Rosenzweig and L.W. Porter, (eds.), _Annual Review of Psychology_, Volume 26, Palo Alto: Annual Reviews, Inc., 1975, pp. 457-480.

**Friedlander, F. and L.D. Brown, "Organization Development" in M.R. Rosenzweig and L.W. Porter, (eds.), _Annual Review of Psychology_, Volume 25, Palo Alto: Annual Reviews, Inc., 1974.

For example, the importance of job design and group interaction variables is illustrated by the following abstract of a recent report by Rousseau;*

> "A review of job design research and sociotechnical systems theory suggests that both of these approaches to organizational change converge in their emphasis on a common set of job characteristics as important to employee satisfaction and motivation. Job characteristics suggested by sociotechnical systems theory and job design research were examined in a survey of employees in 19 production units. These organizational units were classified into three technological categories. Significant differences were found between the job characteristics, employee satisfaction and motivation across technology. In addition, there were substantial positive relations between the job characteristics, satisfaction and motivation. The job characteristics Variety and Task Significance were found to be particularly important to employee satisfaction and motivation."

Note that significant differences across technologies were discovered, suggesting that the job characteristics important for job satisfaction and motivation in pesticide application would have importance, even though the technological features are different from those in many industrial contexts. Also note that the concept of monetary incentives is not mentioned. Rather, the terms <u>job satisfaction</u> and <u>motivation</u> were found to be influenced by such job characteristics as <u>job variety</u> and <u>task significance</u>.

This theoretical distinction between monetary incentives and other job characteristics has been developing in human relations for several years. In a review of studies on <u>job enlargement</u> (i.e., expanding the production scope and responsibility associated with a given job), Lawler discussed the difference as follows:**

> "Before elaborating on this point, it is important to distinguish between two kinds of rewards. The first type are those that are <u>extrinsic</u> to the individual. These rewards are part of the <u>job situation</u> and are given by others. Hence, they are externally-mediated and are rewards that can best be thought of as satisfying lower order needs. The second type of rewards are <u>intrinsic</u> to the individual and stem directly from the <u>performance itself</u>. These rewards are internally-mediated since the individual rewards himself. These rewards can be thought of as satisfying higher order needs such as self-esteem and self-actualization. They involve such outcomes as feelings of accomplishment, feel= ings of achievement, and feelings of using and developing one's

*Rousseau, D.M., "Technological Differences in Job Characteristics, Employee Satisfaction and Motivation: A Synthesis of Job Design Research and Sociotechnical Systems Theory", <u>Organizational Behavior and Human Performance</u>, Volume 19, 1977, pp. 18-42.

**Lawler, E.E., III, "Job Design and Employee Motivation", <u>Personnel Psychology</u>, Volume 22, 1969, pp. 426-435.

skills and abilities. The fact that these rewards are internally-mediated sets them apart from the extrinsic rewards in an important way. It means that the connection between their reception of externally-mediated rewards and performance. Hence, potentially they can be excellent motivators because higher effort-reward probabilities can be established for them than can be established for extrinsic rewards. They also have the advantage that for many people rewards of this nature have a high positive value."

Although the discussion is typical of the human relations literature in its lack of operational preciseness, it is probable that "extrinsic" rewards mean money, extra fringe benefits, better working conditions, and promotions.

The following passage further discusses the notion of "getting promoted" and, provides some good insights for compliance strategies:

> "The evidence indicates that, for a given reward, reward value and the effort-reward probability combine multiplicatively in order to determine an individual's motivation. This means that if either is low or nonexistent then no motivation will be present. As an illustration of this point, consider the case of a manager who very much values getting promoted but who sees no relationship between working hard and getting promoted. For him, promotion is not serving as a motivator, just as it is not for a manager who sees a close connection between being promoted and working hard but who doesn't want to be promoted. In order for motivation to be present, the manager must both value promotion and see the relationship between his efforts and promotion."*

Stated specifically, the <u>rewards</u> must be connected subjectively by the applicator to.the <u>behavior of adhering</u> to the label and, the applicator must (subjectively) value the rewards.

To summarize the discussion thus far, the problem of designing label compliance strategies has been approached from a human relations (HR) and organization development (OD) backdrop, because these disciplines have dealt extensively with concepts such as motivation and job satisfaction. From the HR/OD standpoint, the development of the individual worker is important, but improvement in the sociotechnical context can <u>only</u> occur if the organization "as such" is improved as well.

In the remainder of this appendix, some specific approaches to the problems of motivation and improved application operations will be presented. These approaches will include:

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*Lawler, <u>op.cit.</u>, p. 427.

- Relation of accidents to absenteeism;
- Motivational variables related to absenteeism;
- Motivational variables related to accidents; and
- Behavior modification.

It is not surprising that no specific research is available on the usefulness of these approaches in pesticide misuse contexts. But each of the above listed research categories will provide some guidance toward the objective of designing cost-effective compliance strategies, in terms of methods for design and compliance strategy criteria.

As Castle* points out, the unsanctioned (i.e., unapproved) absence of able bodied workers is not uncommon in heavy industries such as steel making and coal mining where the work is dangerous. These absences are "tolerated", which means they receive some form of management approval. The implication is that the danger of the work exerts some kind of stress or pressure to which the workers respond by absenteeism, and the period of absence enables them to recuperate (emotionally) and return for another period of work.

The study reported by Castle compares accident and absence data for two British plants: a heavy steel making works in Park Gate, and a light industry, Kodak Limited, in Harrow. As shown from Castle's "Table 2" (see Exhibit C-1), accidents and unauthorized absences were dramatically related, even though overall rates per man per year were low. Another implication of Castle's data is that the danger of the industry is associated with disproportionately higher absenteeism. Although the steel workers sustained about twice as many accidents as the Kodak light industry workers, they committed about eight times as many "leaves without permission" on an average per man per year.

These data have exciting implications for analysts who are seeking to understand pesticide applicators' behavior, and for the design of compliance strategies. First, the relation between absences and misuse (or unsafe behavior) can be investigated, and, depending on the connection found, days off from work can be used as a powerful reward for label adherence. The pest control employer may not be inclined to bear the additional labor cost, but it is also possible that some number of man days related to label adherence can be useful in setting the fine for misuse, if the misuse could have been avoided by giving more days off. The implied explanation is that psychological withdrawal from work is the underlying concomitant both of accidents and absenteeism. Additional approved days off might reduce absenteeism but not

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*Castle, P.F.C., "Accidents, Absence, and Withdrawal from the Work Situation", Human Relations, Volume 9, 1956, pp. 223-233, reprinted in D. Porter and P. Applewhite, (eds.), Studies in Organizational Behavior and Management, Scranton, PA, International Textbook Company, 1964, pp. 133-143.

Exhibit C-1: Comparison of Accident and Absence Data for for Different Types of Industries

Forms of Absence at Park Gate and at Kodak
Expressed as Mean Frequency Per May Per Year

	Park Gate	Kodak
Accidents	0.11	0.06
Certified Sicknesses	0.57	0.82
Leaves With Permission	0.83	0.29
Leaves Without Permission	3.08	0.38
Total Absences (excluding accidents)	4.48	1.50

Source: Castle, op. cit., p. 136.

misuse, or it might reduce both. These variables must be investigated for possible usefulness in personnel policies of pest control firms. If absenteeism is an indicator of withdrawal, then it could also be a signal that a change in team composition or a period of retraining is needed.

An additional insight into the nature of absences from work in relation to job characteristics and worker attitudes has been provided by Patchen.* In an extensive study of TVA employees, he collected data on their attitudes toward their jobs as well as the number of absences. The total number of absence occurrences was used, so that periods of two or more consecutive days of absence were counted as one occurrence, thus theoretically minimizing the observed value of absence due to "true" illness. The study group consisted of a sample of 834 nonsupervisory employees (total employment in the TVA system is about 18,000). Although small subgroups within the sample (such as power plant maintenance personnel) have presumably moderately dangerous jobs, no discussion or specific breakout of "dangerous" jobs is given,

Unfortunately, the results of the comparison of absence occurrences with attitudes are not "dramatically" conclusive, as shown from Patchen's Appendix M (see Exhibit C-2). The attitude variables do not include a "job withdrawal" variable which is defined as such. "Control over means" might be an inversely related measure. Here the results of Castle are tentatively supported by a negative .17 correlation (-.25 partial) between "control over means" and absences. On the other hand, "identification with occupation" produced the highest correlation with absences, a positive .39 (+.71 partial). Thus, in the process of designing compliance strategies, it is necessary to analyze carefully the connections among a variety of job and attitude characteristics and absences or misuse.

The Patchen TVA study is important for other contributions as well as the attitude analysis. Patchen presents a more precise formulation of the "motivation model" or "performance model" than is generally encountered. This formulation (see Exhibit C-3) is developed statistically using data collected in the study, thus suggesting a research approach for modeling misuse (or compliance), reminiscent of the one discussed in Chapter 5.

Although the above formulation is reasonably precise, the actual interrelations among the variables (which are really multivariable concepts) are not well distinguished, and the theory is further complicated by an additional formula for "achievement incentive" (see Exhibit C-4), which in the pesticide misuse context would necessarily mean achievement of "correct" application.

Finally, Patchen presents an overall diagram which interrelates all of the previous concepts and elaborates them with some subordinate concepts (see Exhibit C-5). This overall diagram is complicated, but not any more confusing than the broad expanse of HR/OD research literature itself. The researchers expect to operationalize the "expectancy" and "need" variables eventually, by

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*Patchen, M., Participation, Achievement, and Involvement on the Job, Englewood, California, Prentice Hall, 1970.

Exhibit C-2: Indicators of Job Motivation

APPENDIX M. Indicators of Job Motivation, as Related to Characteristics of Job and of Employees

(Multiple Correlation Analyses for 90 Work Groups)

Job and Personal Characteristics	General Job Interest		Interest in Work Innovation		Absences, Total No.	
	r	*Beta*	*r*	*Beta*	*r*	*Beta*
Work difficulty	.25	.06	.45	.38	−.06	−.30
Control over means[a] (Index B)	.33[a]	.12[a]	.31	.28	−.17	−.25
Feedback on performance (Index A)	.11	.03	.22	.11	.25	.03
Time limits, frequency	−.03	−.20	.21	.03	.17	−.28
Chance to learn	.50	.18	.28	−.10	−.08	−.26
Opportunity to compare performance	−.22	−.19	−.09	−.02	−.19	−.18
Clarity of instructions	.19	−.05	.10	.03	−.06	−.17
Need for achievement	−.16	−.08	.08	.08	.18	.12
Peer reward for achievement	.26	.18	.06	.11	−.21	−.26
Promotion reward for achievement	.04	.15	−.02	.03	.16	.14
Supervisor reward for achievement	.34	.12	.25	.06	.05	.16
Identification with occupation	.32	.32	.46	.30	.39	.71
Influence on work goals	.24	.04	.09	.01	−.09	.18
Chance to use abilities	.43	.15	.36	.13	.04	.33
Dependence of co-workers on you	.17	.13	.19	.06	−.22	−.30
Overload of work	−.08	−.06	−.04	−.07	.04	.25
Difficulty getting tools, information, materials	−.09	−.05	.11	−.04	.05	−.10
Chance to finish things	.15	−.14	.06	−.16	−.02	−.04
	$R = .69$[b]		$R = .69$		$R = .73$	
	$R^2 = .47$[b]		$R^2 = .47$		$R^2 = .53$	

a For control over means index A, r with general job interest is .42, and Beta is .26 in a multiple correlation analysis very similar to the one presented here. Control over means index A differs from index B in that it includes the question "How often do you get chances to try out your own ideas on your job, either before or after checking with your supervisor?" This question was omitted from the control over means index in some analyses because the question also appears in the Interest in Work Innovation Index.

b An R of .71 ($R_2 = .50$) was obtained in a multiple correlation analysis which used the same list of predictors with the exceptions that control over means index A and feedback index B were used and overload of work and difficulty getting resources were omitted.

Source: Patchen, op. cit., p. 265.

Exhibit C-3: The Patchen Motivation Equation

$$(1)\ \begin{array}{l}\text{Motive for}\\ \text{Achievement}\\ \text{on the Job}\end{array} = f\left[\begin{bmatrix}\text{Intrinsic Satis-}\\ \text{faction of Achieve-}\\ \text{ment on the Job}\end{bmatrix} + \begin{bmatrix}\text{Expected Satisfaction}\\ \text{in Social Approval and}\\ \text{Respect Which Job}\\ \text{Achievement Will}\\ \text{Bring}\end{bmatrix} + \begin{bmatrix}\text{Other Expected}\\ \text{Satisfactions}\\ \text{Which Job}\\ \text{Achievement}\\ \text{Will Bring}\end{bmatrix}\right]$$

The expected satisfaction in social approval which achievement will bring would be as follows:

$$(2)\ \begin{array}{l}\text{Expected Satisfaction}\\ \text{in Social Approval}\\ \text{Which Job Achievement}\\ \text{Will Bring}\end{array} = f\left[\begin{bmatrix}\text{Motive for}\\ \text{Social Approval}\end{bmatrix} \times \begin{bmatrix}\text{Approval Incentive}\\ \text{(Amount of Social}\\ \text{Approval Which Is}\\ \text{Possible in Job}\\ \text{Situation)}\end{bmatrix} \times \begin{bmatrix}\text{Expectancy That}\\ \text{Achievement Will}\\ \text{Result in Social}\\ \text{Approval}\end{bmatrix}\right]$$

Parallel formulas would predict other expected satisfactions (e.g., higher status, money) which achievement may bring.*

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*Note that by substituting the terms of equation (2) into equation (1), we get the following overall relationship:

$$\begin{array}{l}\text{Motive for}\\ \text{Achievement}\\ \text{on the Job}\end{array} = f\left[\begin{bmatrix}\text{Intrinsic}\\ \text{Satisfaction}\\ \text{of Achievement}\\ \text{on the Job}\end{bmatrix} + \left[\left(M_{\text{approval}}\right) \times \left(I_{\text{approval}}\right) \times \left(E_{\text{approval}}\right)\right] + \left[\left(M_{\text{money}}\right) \times \left(I_{\text{money}}\right) \times \left(E_{\text{money}}\right)\right] \ \text{etc.}\right]$$

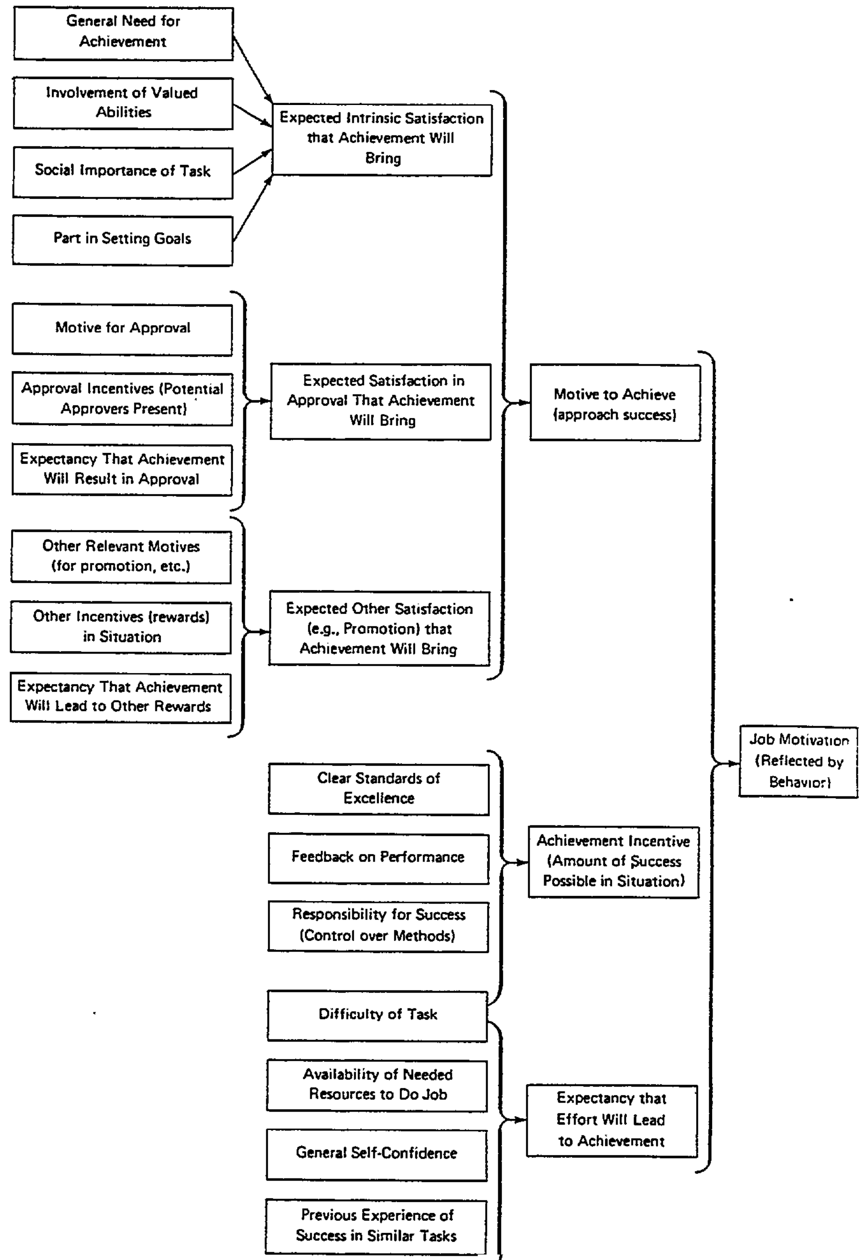
Source: Patchen, <u>op. cit.</u>, p. 31.

Exhibit C-4: The Patchen Achievement Equation

$$\text{Achievement Incentive of a Task} = f\left[\begin{bmatrix}\text{Extent to Which} \\ \text{Standards of Ex-} \\ \text{cellence Are} \\ \text{Clear}\end{bmatrix} \times \begin{bmatrix}\text{Extent to Which} \\ \text{Feedback on Per-} \\ \text{formance Is Ex-} \\ \text{pected}\end{bmatrix} \times \begin{bmatrix}\text{Extent to Which} \\ \text{Person Is Per-} \\ \text{sonally Respon-} \\ \text{sible for Success}\end{bmatrix} \times \begin{bmatrix}\text{Difficulty} \\ \text{of the} \\ \text{Task}\end{bmatrix}\right]$$

Source: Patchen, op. cit., p. 36.

Exhibit C-5: The Patchen Job Motivation Model



Source: Patchen, op. cit., p. 40.

attitude measurement techniques, but as apparent in the results of Patchen's study shown above, it is sometimes difficult to connect the attitude survey results back to the previous concepts.

As mentioned before, it has been difficult to find previous research on the relationship between motivational variables and accidents, i.e., specific operational variables connected both to motivation concepts and also to accidents, defined as undesirable events in sociotechnical contexts that are unpredicted, by at least some people involved. There is one specialized body of research, however, where relatively close approximations to accident or "misuse" models are achieved. This specialized area is that of automobile accidents and driver behavior, and the body of research is certainly not small, although it may or may not be useful in pesticide misuse compliance strategies. A review of social factors involved in highway accidents by McGuire* gives over 60 references and concludes:

> "In summary, it may be said that highway accidents are just another correlate of being emotionally unstable, unhappy, asocial, anti-social, impulsive, under stress, and/or a host of similar conditions under other labels. All of us exist at risk in this mechanized society, and any condition, set of circumstances, or array of personality characteristics which render us less cautios, less attentive, less responsible, less caring, less knowledgeable, or less capable serves to increase this level of risk."

Although the concepts named by McGuire are broad, the highway researchers have not been at a loss to organize and computerize masses of data on driver accident behavior and on the effectiveness of compliance strategies, one of which is called, "driver improvement programs" for drivers "whose records or subsequent condition represent potential risks".** The report by Peck describes a computerized data base for evaluating the effectiveness of a California driver improvement program. A rather typical model of the driver accident situation is presented in Exhibit C-6 (this would be called the sociotechnical context by the HR/OD researchers, but they have not penetrated deeply into the highway accident realm). However, not all of these concepts are operationalized, and in fact, the data stored on computers are those related to issuances of warning letters and to the conduct of hearings. The report mentions data on vision and "physical and mental impairments", data which are available for most drivers from license records, but apparently these data are not used to operationalize the model diagram shown in Exhibit C-6, which intends to predict or model accidents or non-compliance.

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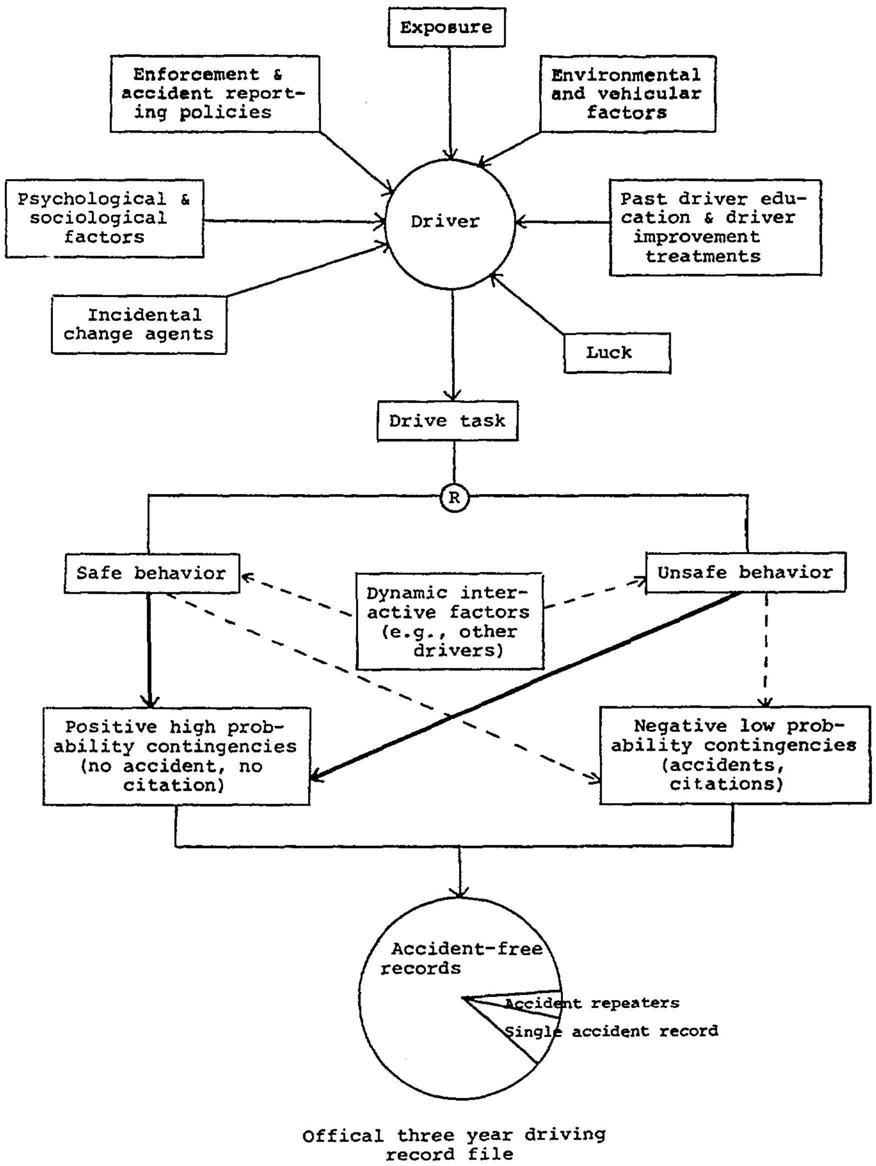
*McGuire, F.L., Human Factors, v. 18, n. 5, 1976, p. 439.

**Peck, R.C., "Toward a Dynamic System for Driver Improvement Program Evaluation", Human Factors, v. 18, no. 5, 1976, pp. 493-506.

Exhibit C-6: Conceptual Illustration of Multiplicity of Factors Influencing Driving Record Over Time and the Small Amount of Differential Reinforcement of Safe Driving



Source: Peck, op. cit., p. 495.

In fact, although several approaches to analyzing social ("motivational" in HR/OD jargon) factors in highway accidents have appeared,* there still is some difficulty, even with masses of data, in getting the models operating, as noted by Klein** in the following abstract of his report:

> "Both the sources of funding for crash research and the characteristics of the investigators attracted to it tend to produce parochialism, segmentation, and specialization in the field as a whole. These potentially divisive forces are counteracted only by a shared and largely uncritical loyalty to the status quo -- that is, a belief that the privately owned and operated conventional vehicle should continue as the major means of transportation. As a consequence, despite the increasingly favorable climate for crash research, recent findings have contributed little to the reduction of mortality and morbidity. The limitations of what is variously called human engineering, engineering psychology, or human factors are delineated, and a broader analytic framework is suggested.'*

Nevertheless, many useful insights and ideas are available from these efforts for use in the pesticide misuse compliance strategy context. These ideas include the use of a computer data base to analyze individual applicator's records of misuse, the development of specific post-misuse training and counselling programs, the monitoring of the effectiveness of these programs, and the conduct of research on the specific behavior preceding and related to misuse. This last idea is discussed by Shaoul.*** The idea presented by Shaoul is that criterion or "indicator" behavior should be identified and this behavior should be measured in drivers who have poor records. Then, driver improvement programs should be designed to change (i.e., modify) these criterion behaviors which include such things as fastening seal belts. This approach sounds like the old industrial safety precautions approach (i.e., "wear safety goggles", etc.), but it is dressed up in the new style of behavior modification.

Literature on behavior modification as a phenomenon indicates that it has arisen from a backdrop of education and therapy rather than from HR/OD (or operations research, which is where the highway safety field originated). Operant learning theory or operant conditioning, which is the foundation of behavior modification, rests on the premise that if desired responses are reinforced (immediately followed) by positive stimuli, these responses will be repeated. In other words, people will act by a set of superimposed rules if they are reinforced for behavior which is in accord with the rules. Hence, behavior modification focuses on the recurring response sequences in behavior patterns and

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*For example, see: Taylor, D.H., "Accidents, Risks, and Models of Explanation", Human Factors, v. 8, n. 4, 1976, pp. 371-380; Shaoul, J.E., "The Use of Intermediate Criteria for Evaluating the Effectiveness of Accident Countermeasures", Human Factors, v. 18, n. 6, 1976, pp. 575-586; and Pelz, D.C., "Driving 'Immunization' in Alienated Young Men", Human Factors, v. 18, v. 5, 1976, pp. 465-476.

**Klein, D., "Social Aspects of Exposure to Highway Crash", Human Factors, v. 18, n. 3, 1976, pp. 211-220.

***Shaoul, J.E., op. cit., pp. 575-586.

attempts to explain these sequences in terms of their results (what stimuli immediately follow).* A quick scan of the behavior modification literature reveals some applications in industry, with studies related to absenteeism, accident rates, and social attitudes.** Thus, this technique would bear further investigation with respect to the reduction of pesticide misuse.

In conclusion, if compliance strategies are devised which pay heed to the industrial safety literature, they will have to be cognizant of:

- The personal/social characteristics of the applicators, including their job attitudes;

- The characteristics of the organization, including control and reward mechanisms; and

- The characteristics of the task, including difficulties, dangers, and inside and outside incentives.

Even if the applicator is a "one-man team" operating alone in a tractor or aircraft, the highway safety researchers have concluded that he is not immune to social (sociotechnical) influences. If he is a professional applicator operating in a team, the situation is more complicated but there are also more approaches for compliance strategies. Thus, with some effort, approaches to compliance strategies based upon this research and theory are possible. Nevertheless, additional research, specifically in the pesticide use/applicator area as outlined in Chapter 5 (pages 110-114), would be useful to "fine tune" this past research for use in the pesticide misuse compliance context.

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*Skinner, B.F., Science and Human Behavior, New York: McMillan, 1953.

**For example, see Pedalino, E. and V.U. Gamboa, "Behavior Modification and Absenteeism: Intervention in One Industrial Setting". Journal of Applied Psychology, v. 59, n. 6, 1974, pp. 694-698, reprinted in C.M. Franks and G.T. Wilson, (eds.), Annual Review of Behavior Therapy, Theory and Practice, New York: Brunner/Mazel, 1976; Castle, P.F., "Accidents, Absence and Withdrawel from the Work Situation", Human Relations, v. 9, 1956, pp. 223-233; McGlade, F.S., Adjustive Behavior and Safe Performance, Springfield; Thomas, 1970; and Suchman, E.A., "Accidents and Social Deviance", Journal of Health and Social Behavior, v. 11, n. 1, 1970, pp. 4-15.

APPENDIX D

SUGGESTED ENFORCEMENT GUIDELINES FOR COUNTIES*

SUGGESTED ENFORCEMENT GUIDELINES FOR COUNTIES

REGULATION	DESCRIPTION	LICENSES: FIRST OFFENSE	LICENSES: SECOND OFFENSE	LICENSES: THIRD OFFENSE	FARM OPERATORS AND OTHERS: FIRST OFFENSE	FARM OPERATORS AND OTHERS: SECOND OFFENSE	FARM OPERATORS AND OTHERS: THIRD OFFENSE
	RESTRICTED HERBICIDES						
2450(a)	Contamination of chemicals and agricultural products by other pesticides	Notice of Violation/Warning	Commissioner's action on registration or permit privileges	Departmental action (1) District Attorney action	Notice of Violation/Warning	Commissioner's interview	Direct citation District Attorney
2450(b)	Dumped or unattended herbicide containers						
2450(d)	Equipment suitable, adjusted, and regulated to prevent drift to restricted herbicide	Stop work order Notice of Violation/Warning	Commissioner's action on registration or permit privileges	Departmental action District Attorney action Direct citation	Stop work order Notice of Violation/Warning	Commissioner's action on permit privileges	Direct citation District Attorney action
2450(e), (g), (h)	Proper application of restricted herbicides by aircraft	Stop work order Commissioner's action on registration or permit privileges	Departmental action District Attorney action Direct citation				
2451(a)	Use of restricted herbicide only under permit	Stop work order Notice of Violation/Warning	Commissioner's action on registration or permit privileges	Departmental action District Attorney action Direct citation	Stop work order Notice of Noncompliance	Commissioner's action on permit privileges	Direct citation District Attorney action

(1) May include: Hearing or filing of complaint.

*Adopted by California Agricultural Commissioners Association, California Department of Food and Agriculture.

Adopted 12/75 C.A.C.A.

EGULATION	DESCRIPTION	LICENSEES: FIRST OFFENSE	LICENSEES: SECOND OFFENSE	LICENSEES: THIRD OFFENSE	FARM OPERATORS AND OTHERS: FIRST OFFENSE	FARM OPERATORS AND OTHERS: SECOND OFFENSE	FARM OPERATORS AND OTHERS: THIRD OFFENSE
451.5	Use report shall be filed within 7 days	Letter or Notice of Warning	Commissioner's action on registration or permit privileges		Letter or Notice of Noncompliance	Commissioner's action on permit privileges	
452(b)	Seller shall obtain permit or signed statement from purchaser	Letter or Notice of Warning	Commissioner's interview	Departmental action			
452.1	Propanil	Stop work order Notice of Violation/Warning	Commissioner's action on registration or permit privileges	Departmental action			
453	Central Valley operations	Stop work order Order of Noncompliance	Commissioner's action on registration or permit privileges	Departmental action District Attorney action Direct citation			
454	Hazardous area operations	Stop work order Commissioner's action on registration or permit privileges	Departmental action District Attorney action Direct citation		Stop work order Commissioner's action on permit privileges	Direct citation District Attorney action Direct citation	
455	Highly volatile liquid	Stop work order Commissioner's action on registration or permit privileges	Departmental action District Attorney action Direct citation				

REGULATION	DESCRIPTION	LICENSEES: FIRST OFFENSE	LICENSEES: SECOND OFFENSE	LICENSEES: THIRD OFFENSE	FARM OPERATORS AND OTHERS: FIRST OFFENSE	FARM OPERATORS AND OTHERS: SECOND OFFENSE	FARM OPERATORS AND OTHERS: THIRD OFFENSE
	RESTRICTED MATERIALS						
2463	Use and possession of restricted material only under permit	Stop work order	Commissioner's action on registration or permit privileges	Departmental action District Attorney action Direct citation	Letter or Notice of Violation/ Warning	Commissioner's action on permit privileges	District Attorney action Direct citation
	COMPOUND 1080						
2471 & 2472	Sale, possession, general use; pest control purposes	Commissioner's action on registration or permit privileges	Departmental action District Attorney action Direct citation		District Attorney action Direct citation		
	PESTICIDE WORKER SAFETY						
2477(a)	Employee shall be 18 years or older to mix or load category 1 or 2 pesticides; except for closed mixing and loading systems	Stop work order Commissioner's action on registration or permit privileges	Departmental action District Attorney action Direct citation		Stop work order Commissioner's action on permit privileges	Direct citation District Attorney action	
2477(b)	Instruction, training, and supervision	Letter of Warning Notice of Violation	Commissioner's action on registration or permit privileges		Letter of Warning Notice of Violation	Action on permit privileges	

REGULATION	DESCRIPTION	LICENSEES FIRST OFFENSE	LICENSEES SECOND OFFENSE	LICENSEES THIRD OFFENSE	FARM OPERATORS AND OTHERS FIRST OFFENSE	FARM OPERATORS AND OTHERS SECOND OFFENSE	FARM OPERATORS AND OTHERS THIRD OFFENSE
2477(c)	Emergency medical care						
2477(d)	Medical supervision						
2477(e)	Working alone with pesticides in Toxicity Category 1	Stop work order Commissioner's action on registration or permit privileges	Departmental action District Attorney action Direct citation		Stop work order Commissioner's action on permit privileges	Direct citation District Attorney action	
2477(f)	Loading agricultural aircraft with Toxicity Categories 1 or 2						
2477(g)	Change area when Category 1 or 2 materials are applied	Letter of Warning Notice of Violation	Commissioner's action on registration or permit privileges		Written warning	Commissioner's action on permit privileges	
2477(h)	Personal washing facilities at mixing and loading site	Stop work order Notice of Violation	Commissioner's action on registration or permit privileges	Departmental action	Stop work order Notice of Violation	Commissioner's action on permit privileges	District Attorney action
2477(i)	Protective clothing, safety equipment, and safety procedures						
2477(j)	Safety procedures in the pesticide labeling						

REGULATION	DESCRIPTION	LICENSEES			FARM OPERATORS AND OTHERS		
		FIRST OFFENSE	SECOND OFFENSE	THIRD OFFENSE	FIRST OFFENSE	SECOND OFFENSE	THIRD OFFENSE
2477(k)	Adequate light at mixing and loading site						
2478(a)	Equipment used for mixing, loading, or applying pesticides shall be in good repair and safe to operate	Stop work order Notice of Violation	Commissioner's action on permit privileges	Departmental action District Attorney action	Stop work order Notice of Violation	Commissioner's action on permit privileges	District Attorney action
2478(b)	Equipment maintenance	Notice of Violation/Warning	Commissioner's action on registration		Notice of Violation Written warning	Commissioner's action on permit privileges	
2480	<u>SAFETY FOR PERSONS ENTERING FIELDS AFTER PESTICIDE APPLICATIONS</u>				Stop work order Direct citation	District Attorney action	
2481	Warnings				Stop work order Notice of Violation or direct citation	Direct citation District Attorney action	
482	Records				Letter of Warning Notice of Violation	Commissioner's action on permit privileges	

REGULATION	DESCRIPTION	LICENSEES			FARM OPERATORS AND OTHERS		
		FIRST OFFENSE	SECOND OFFENSE	THIRD OFFENSE	FIRST OFFENSE	SECOND OFFENSE	THIRD OFFENSE
	PEST CONTROL OPERATIONS						
3090	Equipment Identification	Notice of Violation/Warning	Commissioner's action on registration				
3090.1	Accidental Pesticide Release Reports	Commissioner's action on registration	Direct citation District Attorney action Departmental action		Commissioner's action on permit privileges	Direct citation District Attorney action	
090.2	Pest Control Records	Letter or Notice of Violation/ Warning	Commissioner's action on registration or permit privileges				
3091(a)	Equipment in Good Repair	Notice of Violation/Warning	Commissioner's action on registration or permit privileges		Letter or Notice of Violation/ Warning	Commissioner's action on permit privileges	
3091(b)	Use Properly Calibrated Devices						
3091(c)	Maintain Uniform Mixture	Stop work order Commissioner's action on registration or permit privileges	Departmental action District Attorney action Direct citation		Commissioner's action on permit privileges	District Attorney action Direct citation	

REGULATION	DESCRIPTION	LICENSEES FIRST OFFENSE	LICENSEES SECOND OFFENSE	LICENSEES THIRD OFFENSE	FARM OPERATORS AND OTHERS FIRST OFFENSE	FARM OPERATORS AND OTHERS SECOND OFFENSE	FARM OPERATORS AND OTHERS THIRD OFFENSE
3091(d)	Perform Work in Good Workmanlike Manner						
3091(f)	Methods and Operations to Insure Proper Application	Commissioner's action on permit privileges Stop work order	Commissioner's action on registration	Departmental action District Attorney action Direct citation			
3091(g)	Apply During Suitable Climatic Conditions						
3091(h)	Avoid Water Contamination	Stop work order Commissioner's action on registration District Attorney action			Stop work order Commissioner's action on permit privileges District Attorney action		
3092(a)	Use of Pesticide in Conflict With Label	Stop work order Commissioner's action on registration or permit privileges	Departmental action District Attorney action Direct citation		Stop work order Commissioner's action on permit privileges	District Attorney action Direct citation	
3092(b)	Use of Unregistered Product Without Experimental Use Permit	Stop work order Written warning	Commissioner's action on registration or permit privileges	Departmental action District Attorney action	Stop work order Written warning	Commissioner's action on permit privileges	District Attorney action
3093(a)	Persons within or near treated area	Stop work order Commissioner's action on registration or permit privileges	Departmental action District Attorney action Direct citation		Stop work order Commissioner's action on permit privileges	District Attorney action Direct citation	

REGULATION	DESCRIPTION	LICENSEES FIRST OFFENSE	LICENSEES SECOND OFFENSE	LICENSEES THIRD OFFENSE	FARM OPERATORS AND OTHERS FIRST OFFENSE	FARM OPERATORS AND OTHERS SECOND OFFENSE	FARM OPERATORS AND OTHERS THIRD OFFENSE
3093(b)	Crops, animals, property damage						
3093(c)	Pesticide Not Confined to Treatment Area						
3094(b)	Application on Property Without Consent	Stop work order Commissioner's action on registration or permit privileges	Departmental action District Attorney action Direct citation				
3094(c)	Give Warning to Property Owner Prior to Treatment	Commissioner's action on permit privileges or registration	Departmental action District Attorney action				
3096	Failure to Notify Beekeeper	Commissioner's action on registration or permit privileges	Departmental action District Attorney action				
3097	Failure to Take Precaution When Using Flammable or Explosive Material	Stop work order Commissioner's action on registration or permit privileges Direct citation	Departmental action District Attorney action		Stop work order Commissioner's action on permit privileges Direct citation	District Attorney action	
	AGRICULTURAL PEST CONTROL ADVISERS						
3122	Must register with County Agricultural Commissioner	Commissioner interview	District Attorney action				

REGULATION	DESCRIPTION	LICENSEES			FARM OPERATORS AND OTHERS		
		FIRST OFFENSE	SECOND OFFENSE	THIRD OFFENSE	FIRST OFFENSE	SECOND OFFENSE	THIRD OFFENSE
3123(a), (b)	Recommendations shall be in writing have required information, delivered to proper parties	Letter or Notice of Violation/ Warning	Commissioner's action on registration	Departmental action			
	PESTICIDE DEALERS						
3131(a), (b)	Prepare and Maintain Records of all Sales or Deliveries	Notice of Violation Written warning	Commissioner's action on registration	Departmental action			
	STORAGE TRANSPORTATION AND DISPOSAL						
3136(a), (b)	Storage, Disposal, and Control of Pesticide containers	Notice of Violation/Warning	Commissioner's action on registration Direct citation	Departmental action District Attorney action	Notice of Violation/Warning	Commissioner's action on permit privileges	District Attorney action Direct citation
3137	Delivery of:						
3138	Posting of Storage Area						
3138.1	Storage Recommendations						
3139	Pesticides in Food Containers	Commissioner's action on registration District Attorney action Departmental action			District Attorney action		

REGULATION	DESCRIPTION	LICENSEES FIRST OFFENSE	LICENSEES SECOND OFFENSE	LICENSEES THIRD OFFENSE	FARM OPERATORS AND OTHERS FIRST OFFENSE	FARM OPERATORS AND OTHERS SECOND OFFENSE	FARM OPERATORS AND OTHERS THIRD OFFENSE
3141	Rinse and Drain Procedures	Notice of Violation/Warning	Commissioner's action on registration or permit privileges	Departmental action District Attorney action Direct citation	Notice of Violation/Warning	Commissioner's action on permit privileges	District Attorney action Direct citation
3142	Disposal of Rinsed Containers						
3143	Disposal of Pesticides and Rinsed Containers						
3144	Disposal of Dry Pesticide Containers						

TECHNICAL REPORT DATA
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16. ABSTRACT

Under the Federal Insecticide, Fungicide and Rodenticide Act, it is unlawful for any person to use any registered pesticide in a manner inconsistent with its labeling (Section 12(a)(2)(G), as amended). This report demonstrates the necessity and feasibility of developing a methodology for designing cost-effective monitoring and compliance programs to deal with pesticide misuse.

Because such a methodology was found to be within the limits of current state-of-the-art technology and organizational structures, the report provides a generalized design technique for pesticide regulatory agencies. The methodology consists of techniques for analyzing the scope and effects of misuse, ranking misuse according to potential damages, monitoring misuse and damages, analyzing and modeling user procedures, and evaluating compliance strategies. Additional work would be required to develop specific compliance strategies from the general approaches presented.

Although the need to do such work is defensible, potential users must view the methodology as being a useful tool before the work is performed. Consequently, a series of recommendations are presented for further formulating, testing, and implementing the procedures presented in the report.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Monitors Regulations	Pesticide Use	68E
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